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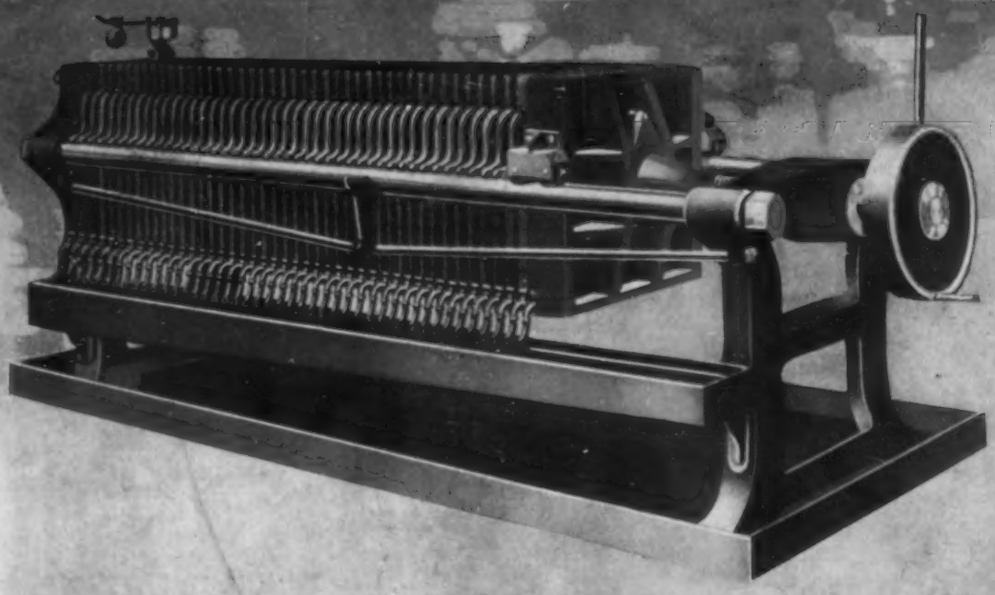
CHEMICAL & METALLURGICAL ENGINEERING



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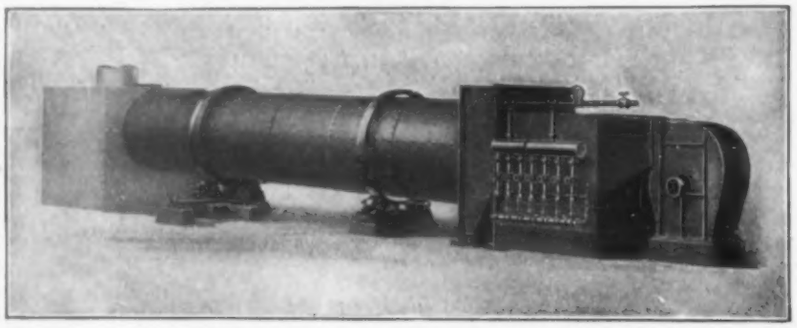

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The Dawn of Peace

WITH whatever feelings we may have contemplated the procedure of the Peace Conference at Paris, there could be but one universal sentiment at the announcement of the Germans that they were ready to sign the treaty unconditionally. Men everywhere experienced a sense of relief, a feeling that the world had at last finished a nasty job and could go about its business, could afford to take at least one eye off the enemy and apply it to works of construction. True, events immediately subsequent to the declaration showed that not more than one eye could be detached for the present, and that watchfulness would be in order for some time to come. It is true also that the world still awaits retributive justice in the trial of those responsible for the war and the payment of indemnities to ravished Belgium and France. But on the whole there is a feeling that the pursuits of peace can occupy our attention. There will still be much political debate and argument, despite Lincoln's historic and classic recognition of the fact that "the world will little care or long remember what we say here," but that need not deter industry from putting its hand to the throttle and forging ahead. The future will be determined more by work than talk.

Co-operation Between Industry and University

WE PUBLISH in another column a letter from a student of chemical engineering in which the prospectus of an intercollegiate chemical society is outlined. It has for its purpose the establishment of a course of lectures on the technology of various industries and the details of large-scale chemical apparatus. The idea seems to us worth while. There is a considerable hazard of loss in breaking in nearly every student to factory practice, and this should be decreased by the course proposed. A trouble that has not been provided for in these lectures by manufacturers, works chemists and sales engineers of apparatus is that men who are not accustomed to lecturing are fully likely not to consider their time and get to the point without needless preambles and peroration. Usually it is like pulling teeth to draw information out of an unregenerate manufacturer—and by unregenerate we mean one that fears his neighbor as the devil, and who holds that all information relating to his industry should be privy to his establishment.

What we would like to see in chemical engineering courses is better training in industrial physics. After all it is more important to know why things are done and why results ensue then to learn how to do them. It takes very little explaining to teach a man how, who knows why.

Is Molybdenum a Metallurgical Mystery?

ONE of the minor metals which has witnessed some puzzling vicissitudes in fortune during war-time is molybdenum. Ten-fold increase in price caused quadrupling of output, whereupon the market became more or less nominal, and has remained stagnant for several months. Under these circumstances, miners of this material are naturally much concerned about the chances of future business, especially since molybdenum minerals are much more widespread and accessible than others, tungsten or vanadium as instances, and any probable demand could be readily satisfied.

Contradictory statements as to its uses have been so current as to dub molybdenum "the metallurgical mystery." KRUPP did absorb a great proportion of the available supplies, and captured German gun tubes have been variously reported as containing from zero to 6 per cent. No information as to similar use by an Allied government has come to notice. While the metal has a high melting point, it is said to change very readily into a volatile oxide, so that silver plating is necessary to get the alloy into the metal rather than the slag. Some gun tubes may have been de-molybdenized by heat, other analyses may have unfortunately confounded this element with carbon, while again, still others may have always been innocent of its presence, possibly due to the high price of silver!

Seriously, though, molybdenum steel is a demonstrated success. Quantities of it have been used in aëroplane engines, while many liberty motor crank shafts were made of a manganese-chromium-molybdenum alloy. Following extensive experimentation, one prominent automobile maker in the Detroit region ordered 10,000 tons of a special alloy containing a fractional per cent molybdenum, which is being used in forged or case-hardened parts demanding high strength and low weight. As such it should replace the vanadium steels already well established, owing to the comparative rarity of vanadium and to the fact that the new alloy does not require such close control in heat treatment; perhaps molybdenum acts as a brake in spreading transformations over a wider temperature range. The addition of molybdenum to nickel steels in small quantities increases the ductility remarkably.

Such are the uses of the future. At present considerable quantities of molybdenum are absorbed by tool-steel makers—the element is almost always present in modern metal-cutting tools.

Even granting the fact that molybdenum steel is a demonstrated high-strength material, it certainly will not be a panacea for all heat-treating troubles, and it is difficult to see any great boom in molybdenite in the

near future. Mines and mills are already developed to such an extent that should their present excess capacity be put into molybdenum steel (averaging perhaps 1 per cent), 250,000 tons of this material would be produced per year. Picture the metallurgical knowledge which must be accumulated before iron-masters will be able to deliver uniform steel of this comparatively new analysis, the many obscure troubles which arise in the manufacture of the completed parts—some wholly new and baffling defect may vie with the notorious "flakes" of nickel steel in keeping metallurgists awake nights—picture the campaign of education necessary to make the purchasing agent recognize its value and the purchasing public demand minimum weight with maximum strength, and the conclusion is inevitable that widespread demand for molybdenum as a constituent for steel will not be a matter of months.

A Rose By Any Other Name—

ELSEWHERE in this issue the reader will find a communication from the house of Kuhlmann, Paris, protesting against the assumption of the German origin of its founder. Exception is taken primarily to a statement of Landis in his article on the oxidation of ammonia, to the effect that "eighty years ago Kuhlmann, a German technical chemist, etc.;" and proof is now offered that Kuhlmann was "a savant doubly French." We are glad to give space to the correction as further evidence of the myth of German preëminence in chemistry, which is growing less persistent as the facts in the history of chemistry come to light.

If we may boldly claim in this instance to represent average American intelligence among chemists, we can readily understand how Mr. Landis and probably the great majority of our readers, would accept innocently enough and quite as a matter of fact, a statement that Kuhlmann was a German chemist. For have we not been nurtured in the belief that chemistry and Germany were synonymous, and that the abode of chemical knowledge was beyond the Rhine? Couple this with the typical spelling of Kuhlmann, and we have all the elements necessary to an erroneous conclusion. But it appears that Kuhlmann was born in Colmar, Alsace, in 1803; was subsequently professor of chemistry in the University of Lille, and later founder of the 40,000,000-franc Etablissements Kuhlmann in Paris and elsewhere in France. He was a Frenchman by birth, education and all that characterizes one's nationality and mentality.

The last five years have developed awkward situations regarding the merits of the scientific and technical contributions of the several nations. It has been easy to foster extreme views and share partisan feelings. A large number of American technical men were of foreign birth or education. German literature had been widely read in this country, and it was perhaps logical that we should have assumed that Germany had led the way in all chemical progress. We have learned, however, that names are not safe tags of identification as to the nationality and mentality of the world's scientists; and in the present instance we are delighted to know that it was a French savant who early recorded the importance of the oxidation of ammonia to nitric acid. We render unto Caesar the things that are Caesar's and acclaim a French scientist even though he bears a German name.

Need of a Firm Policy in Mexico

WITH European affairs less engrossing than they have been for several years the United States has an opportunity to turn much needed attention to its Mexican relations. They need attention! For almost 10 years the interests in American mining and metallurgical companies operating in Mexico have suffered from the lack of protection of life and property. Murder, robbery, pillage and banditry have been committed and practised without effective interference or suppression and almost without protest. If the Government has had reasons for pursuing a weak policy with our Southern neighbor those reasons have not been disclosed to the country's satisfaction, and the people are beginning to feel that it is about time to abandon patience and yield to the impulses of righteous wrath. The policy of watchful waiting finds us still watching and waiting after nearly a decade, but almost hopeless of a firm governmental policy that will insure protection to Americans and their property. Conditions have been unsettled for so long that we have almost come to regard them as inevitable and something to be endured without remedy.

But there are hopeful signs. Congress has recently pressed the Administration for a statement of its policy, and Under-Secretary of State Polk is reported to have spoken "with complete frankness" to the House Committee on Foreign Affairs, laying the Administration's cards on the table. Firing across the border into El Paso has been stopped by an excursion of American soldiers into Mexican territory, apparently with Mexico's acquiescence. Of more than ordinary importance is the action of the Mining and Metallurgical Society of America in proposing resclutions of protest

> "against further disregard by the American Government of conditions in Mexico that make it unsafe for American engineers to go there in the practice of their profession and for the care of business interests intrusted to them";

and further urging

> "the American Government to take prompt and effective steps toward the establishment of such law and order in Mexico as will safeguard the persons and property of our citizens and extend its protection to all Americans in any part of the world to which they may be called in the pursuit of their legitimate affairs."

The Society is to be commended for this evidence of interest in Mexican affairs, and we see no reason why the American Institute of Mining and Metallurgical Engineers should not go on record with similar resolutions reflecting the attitude of the great mining industry. The Institute has recently amended its charter to permit participation in public affairs and expression of opinion on public questions affecting its members. At the moment we can think of no more opportune theme for the exercise of the Institute's newly acquired powers than advocacy of a firm governmental policy in Mexico. Dignified representation to the Government by influential bodies of citizens will hasten the dawn of a new era in Mexican relations that will be mutually beneficial. The people of the United States have been more than long-suffering in this matter, not only in toleration of Mexican lapses, but in refraining from unkind criticism of the Government's policy, whatever it may be. The elements of the situation seem to be comparatively simple and the remedy effective. It is futile to talk of Mexico's national honor when our own country is humiliated and insulted.

Automatic Control Devices In the Chemical Industries

TRUE to American traditions begun by substituting the harvester for the scythe, our inventors have not failed to design automatic mechanism endowed with about as much cerebellum matter as is required in ordinary routine work. The cobbler had his destiny foretold by the experiences of the nailsmith and the weaver. Is it only a matter of time before the chemical control operator will follow suit and pass his skill to the tools of which he will be merely a tender?

Tank gaging is far better done by the hydrostatic pressure recorders now coming into vogue than was ever accomplished by the most exact calculations obtained from volume and temperature measurements. Temperature control is almost an undisputed job for the thermostat. Solution gravities, concentrations, viscosities—all are coming within the scope of the automatic control devices operated by buoyancy floats, electrolytic conductivity or resistance balances, propelling resistance recorders, and similar apparatus.

The fairest solution of the question appears to be found upon examining the experience of the artist since the era of the camera. In the early days when sensitive plates were made with asphalt-lard coatings, and turpentine was the solvent used to dissolve the parts not polymerized by light, photography appeared unlikely ever to become a member of the fine arts. However, developments came about which demonstrated that the camera shutter was not to be a portal for the exit of the artist but an arch of triumph for conquests in science as well as art. The same must be true of such devices in the hands of the engineer. He must not be satisfied with rough initial developments and, above all, must not have the feeling that he will work himself out of a job by doing what he can toward developing automatic control devices. Relief from routine work will give the chemist opportunity for larger development.

Stability of Prices and Employment

IN time of prosperity one should prepare for adversity and *vice versa*. Business is prosperous, and is certain to be more so, for a period of years. Panics and industrial depressions can, perhaps, be prevented but the method has not yet been invented, much less put into execution. To err is human, and these occurrences result from the errors of men.

There are important new conditions, and if panics and depressions occur they will exhibit different phenomena than formerly. The Federal Reserve system, according to the judgment of experts, removes the possibility of a "money panic." The organization of labor, and the new ideals of labor, make it improbable that men will compete for work to the extent they have done in past industrial depressions. The depression of 1873-8 saw "dollar-a-day" labor, and in the depression of 20 years later there was the same development. Men are almost certain to insist, when there is not enough work for full employment, that the work be divided and hourly rates be maintained.

This change, by itself, would make an industrial depression more severe. When commodities are sold, or service rendered, whether the furnishing of electric current or the removal of dirt from one's clothes, part of the payment goes to the workmen involved and part to the capitalist who furnishes the facilities. If the volume of business decreases and the one party stands none of the loss the other party must stand a correspondingly greater loss. When capital does not secure a return there is no creation of fresh capital such as in times of prosperity would be reinvested and make more work for the people. Moreover, if the cost of labor does not decline the inducement of cheapness to the making of investments is removed. A census of the skyscraper office buildings in the country would probably show that the majority of them were placed under contract in times of relative depression.

Recurring to the Federal Reserve system, it provides means whereby funds can be secured by those who have credit. In the past such facilities have been largely lacking. To provide absolutely necessary funds capitalists have had to operate plants at a loss, not getting a new dollar for an old one. Such performances probably will be unnecessary.

Thus in the new order of things it seems probable that when there is a tendency to industrial depression both labor and capital will refuse to work for less money reward than formerly and thus the traditional readjustment will not be encouraged. It is not intended to deny that the probable occurrence of panics, other than money panics, and of industrial depression has been reduced. It certainly has not been shown, however, that the reduction is to zero, and it does seem clear that if such things do occur the means for recovery are reduced. It is like reducing the likelihood of the human system to yield to disease but at the same time reducing its power to throw off the disease, once the infection has occurred.

Every year brings its own joys and sorrows and so do changing conditions. The outlook for the investor is not gloomy, but bright, for there is another new condition that makes capital more valuable than ever. Common labor in the United States, over periods of years, will never be as plentiful as it has been. That comes from sociological and racial conditions, not from business or financial conditions, and represents a permanent change. As less work is to be done by common labor more work must be done by capital, by the creation of plant facilities pursued to the *n*th refinement of labor-saving efficiency. Instead of there being no room for new investments there is vastly more room than ever before, since the new labor conditions make the existing facilities much less efficient, relative to the supply of labor, than formerly.

What is necessary is that the investor be able to earn enough in the first few years of operation to safeguard him in case industrial depression comes. The investor must look upon this matter from a new viewpoint. In the past his philosophy has been that he must amass sufficient extra profit to enable him to write off a large sum from the investment to cover reduction in cost of duplication. In the new order of things such declines in the cost of duplication are likely to be much less severe than formerly but on the other hand the chances of unemployment may be greater. The investor should save, therefore, against the temporary period when his investment may yield no profit. It is clear, also, that the sooner one makes his investment and begins securing returns upon it the safer he will be for the future. Delay undoubtedly means loss. The world is going to move, and move rapidly, and one should move with it.

Readers' Views and Comments

Oxidation of Ammonia

To the Editor of Chemical & Metallurgical Engineering

SIR:—In your issue for May 1, 1919, we note an article by W. S. Landis on the Oxidation of Ammonia, in the first paragraph of which occurs the following statement:

"Eighty years ago Kuhlmann, a German technical chemist, after describing at length some very interesting experiments of his own, concluded with the significant remark, etc. . . ."

For reasons which are readily understood it is impossible for us to overlook the error in this statement regarding the nationality of Kuhlmann, who was a savant doubly French, because he was born in Colmar (Alsace) in 1803. Frederick Kuhlmann was professor of chemistry at the University of Lille, the great industrial city of Northern France, and it was there that he made a great number of researches in the domain of pure and applied chemistry.

Most of his works were first published in the Bulletin de la Société des Sciences de Lille; others in the Annales de Physique et de Chimie (de Paris).

His discovery of the oxidation of ammonia by catalysis with spongy platinum was described for the first time in a memoir entitled "Mémoire sur la Nitrification" published in Vol. 15 of the Bull. de la Soc. des Sc. de Lille which contains the reference cited by Mr. Landis.

Ingenious manufacturer as well as a great savant, Kuhlmann installed in 1825 in Lille a sulphuric acid plant, which was the cradle of the Kuhlmann plants now numbering 15 scattered all over France.

He died in 1881, correspondent member of the Academie des Sciences de Paris and Commander of the Legion of Honor.

At a time when the masterful discovery of Kuhlmann, exploited by a German, Ostwald, is justifying the prophecy of the French savant, we consider it our duty to attract the attention of our American friends to the evident involuntary error made by Mr. Landis, and we would be greatly obliged if you would make due correction in an early issue of CHEMICAL and METALLURGICAL ENGINEERING, for which we present you our thanks in anticipation.

ADMINISTRATEUR DELEGUE
ETABLISSEMENTS KUHLMANN

Paris, France.

Chemical Technology for College Students

To the Editor of Chemical & Metallurgical Engineering

SIR:—An authority on education once said that a fault of modern technical institutes was the failure of the instructors to establish proper relationship between book knowledge and practical, everyday technology. This is also true of chemistry, which brings me to the purpose of this letter.

There is in process of formation an organization called the Intercollegiate Chemical Society, the main purpose of which is to correct this condition. The following is an excerpt from the preamble to its constitution:

"It is highly desirable, especially in the undergraduate courses, to connect chemistry with the world of commerce as it has not been connected. This can easily be done by the co-operation of students and manufacturers. Many potential chemists have been lost because the applications of science have not been made apparent in lectures or laboratory work."

The Intercollegiate Chemical Society proposes to accomplish its purpose by inducing prominent manufacturers or members of their technical staffs to lecture to its members, if possible every fortnight, showing the technology of various processes and apparatus, and indicating the applications of laboratory practice to factory control. These would be supplemented by demonstrations on trips with the students through plants, whenever practicable.

The officers of the society are prepared to send to any manufacturer who is willing to contribute aid in this connection, a calendar of subjects studied, so that demonstrations of apparatus and lectures in industry may be co-ordinated with the course. The academic calendar includes thirty weeks of actual work. This provides for fifteen such discussions or demonstrations during the year. If we can secure the co-operation of that number of manufacturers, each will be asked for but one discussion or demonstration per year.

We are organizing branches of the society in a number of universities throughout the States and the purpose of this is to ask manufacturers in the chemical and allied industries to co-operate. I have spoken to a number of men well known in industrial circles and they believe the advantage that can be derived from such a plan will prove profitable to both students and manufacturers. With such training a student will be made more efficient and can take up his duties when entering an industrial plant with less likelihood of loss and delay by the exigencies of "breaking him in."

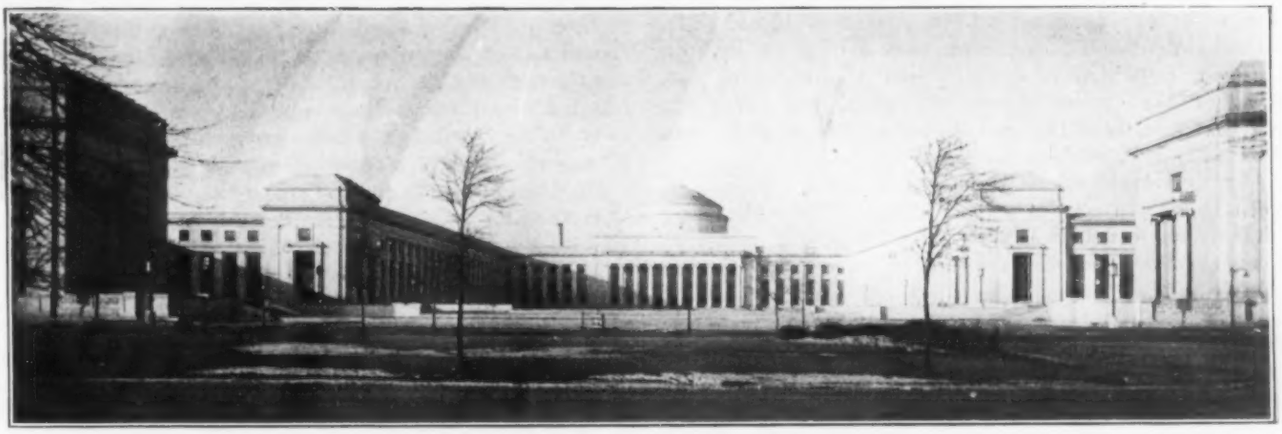
Students should have a more thorough understanding of the needs of chemical industries. This knowledge, combined with the fundamentals gained at the university, will help them recognize and eliminate wastes and increase yields as they advance in technical development. It will be an efficient way to connect theoretical chemistry with actual industrial conditions. It will also develop a tendency for young chemists to seek methods in which the achievements of pure science may be brought ever closer to industrial practice.

If manufacturers who are interested in providing for such demonstrations of industrial practice, or of apparatus which they make, will communicate with me I shall be glad to respond with whatever additional information they may desire. H. GROSSMAN,
Acting Chairman.

Intercollegiate Chemical Society,
Columbia University, N. Y.

Surplus Government Lead

By arrangement with the Lead Producers' Committee of the War Industries Board, sufficient orders will be allocated to the War Department to take up the surplus stock of pig lead, which does not exceed 5000 tons. In addition, about 10,000 tons of heavy sheet lead, 25 tons of lead pipe and 6 tons of lead slabs will be disposed of without the assistance of the industry. The Director of Sales is also seeking a market for 1180 tons of antimonial lead and approximately 930 tons of antimonial lead scrap.



MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Meeting of American Institute of Chemical Engineers

Large Gathering at Boston and Cambridge—Interesting Visits to Places of Historical and Industrial Interest—Massachusetts Institute of Technology, A. D. Little, Inc., Harvard University—Symposium of Electric Furnaces

THE eleventh semi-annual meeting of the American Institute of Chemical Engineers at Boston and Cambridge, June 18-21, does not lend itself readily to a brief description. The excursion on the steamer "Gurnet" was the unique feature. Mr. Henry Howard, Director of the Emergency Fleet Recruiting Service and sometime of the Merrimac Chemical Co. endeavored to demonstrate by the trip to sea in the "Gurnet" just why he had such great interest in maritime pursuits. The Boston Fish Piers were visited first in order to furnish fresh material for future fish stories as well as to entrance all angling desires. About a million pounds per day of cod, haddock, mackerel, etc., were said to be the average of the season. Inspection of the cold storage department demonstrated that ample provisions have been made for many Fridays to come.

The second stop was made at the plant of the Revere Sugar Refinery. Thousands of tons of crude sugar, the Cuban in 200-lb. burlap bags and the Philippine in 50-lb. palm platted sacks, were stacked in the pier warehouses. In refining, the sugar is dissolved, limed and filtered in Sweetland presses. The syrup is then clarified by percolating it through animal charcoal and is then ready for crystallization in vacuum pans. After the grains have grown to the desired size, the sugar is discharged into open bins from which it passes into centrifugals, is freed from molasses and flushed with water sprays to remove both the finer crystals and syrup. Two or three percent of moisture remains in the centrifuged product and is removed in forty foot drum driers. The engineering involved in such a works is a model for the crystal type of chemical process. Every task is performed with a minimum expenditure of energy and labor. After the initial elevating of the crude syrup to the top floors, gravity does the rest. The packaging machinery was exceptionally good and since space does not permit more discription, only the names will be given. Bag Machine: Richardson Scale Co., Passaic, N. J. Bag Sewing Mach.: Union Special Machine Co. Chicago. Package Filler and Sealer: Pneumatic Scale Co. Norfolk Downs, Mass. Box Nailer: Morgan Machine Co. Rochester, N. Y.

While enroute to the Victory Shipbuilding plant at Squantum, the Edison Power Plant was passed. Also a brief inspection was made at the seamen training school. The visit to the Victory yard gave an excellent opportunity for a study of modern steel fabrication. Hundreds of riveting gangs put added vigor to their tasks and the red hot battered rivet heads in cooling drew the steel plates tightly together. In order that there should be no seams for water leaks at the joints, the calkers rammed the edges of the plates so that they were sprung flush. From the storage yard to the fitting out basin in a quarter of an hour was too brief a time to observe details. It is enough to say that torpedo boat destroyers will never be out of sight on our coast after a few years more of standardized fabrication.

Enthused after so many excellent plant visits along Boston harbor, the voyaging members did not seek to break away before the final event of the day—the trip out in the open water of Massachusetts Bay to Marblehead. The Gurnet being a small steamer of fifty odd feet length was soon effectively rocking and much to the satisfaction of the fishes. Of the one hundred and twenty six passengers, only half were found by the photographer the next day in happy enough condition to have their appearance registered in the annual June meeting panorama.

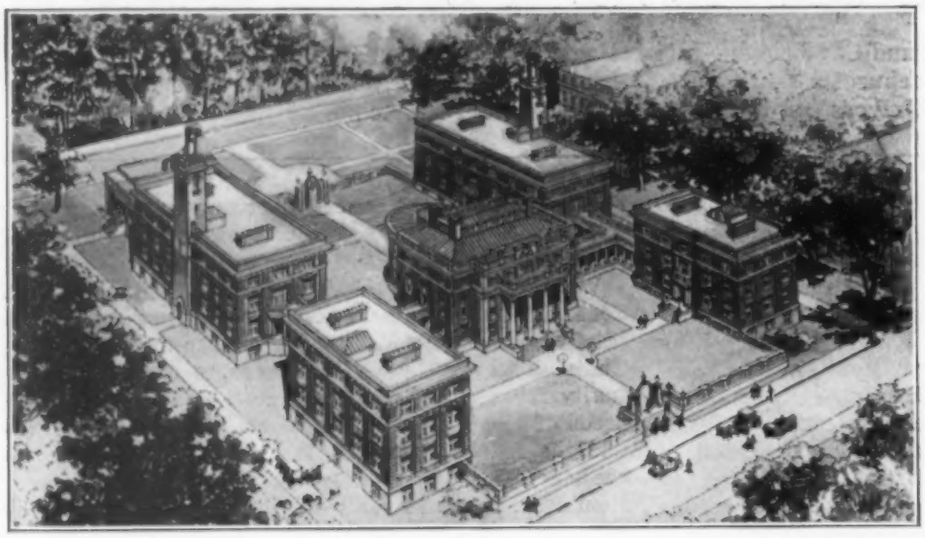
Laboratories in Cambridge Visited

On Wednesday night, a smoker was held in the assembly room of the A. D. Little, Inc. building. Every one was delighted with the arrangement of the laboratories and officies.[1] The paper mill was in operation and demonstrated the facilities with which Dr. Little's staff is equipped to carry on research in most of the large industrial chemical enterprises. The museum gave

[1]For description see Chem. & Met. Eng., Vol. XIX, P. 100.

additional evidence of the great scope of their work and contains specimans of the greatest value. Mr. Ellwood Hendrick gave a humorous exhibit on electron furnaces in which he transformed a mixture of saw dust and like miscellaneous materials into fresh hot roasted peanuts. The remainder of the evening was devoted to fun, refreshments and song.

The new buildings of the Massachusetts Institute of Technology are marvelously compact. The right wing of the inner court, over which the illustrious names of Pasteur and Lavoisier are carved, is devoted to the chemical departments. The laboratories are, it is needless to say, the best that could be built. It comparing the chemical engineering equipment with that of some of the other engineering laboratories, the casual visitor might think that there was room for considerable improvement. The commercial size hydraulic, steam and electric power plants make the small Swenson evaporators look small indeed and they are the giants of the industrial chemical laboratory. However, Prof. Walker has overcome these difficulties and set all the other engineering divisions a new example. Technology instructors are now placed in several of the chemical plants around Boston and the students are given more than the birdeye view of the manufacturing business.



DIVISION OF CHEMISTRY, HARVARD UNIVERSITY

The Wolcott Gibbs Memorial Laboratory[1] is the forerunner of what might be called the Harvard College of Chemistry. A view of the group of buildings as now planned by the architect, Mr. A. W. Longfellow, is given. Dr. Morris Loeb, Mr. James Loeb, T. Jefferson Coolidge and several members of the alumni are the donators of of the first two buildings. These buildings will be instrumental in the development of pure and applied chemistry for generations to come and it is certainly a rare privilege that wealth has bestowed upon the founders which will enable them to contribute so much to the future welfare of humanity. Professor T. W. Richards personally welcomed the Institute. Though he was able to show the prize points of the laboratory such as 6-ft. drawers and other extraordinary facilities for research, the guests knew that their real opportunity was in visiting America's greatest chemist in the building entirely devoted to research under his guidance.

[1]For full description see Harvard Alumni Bulletin, Vol. XV, No. 26, P. 424-429.

President A. D. Little introduced an amendment to the method of selecting candidates for membership whereby the admission committee could place those candidates up for election who do not quite meet all the specifications but have real meritorious qualifications. It is hoped to make the Institute the real representative body of the American chemical technologists and engineers.

Dr. David Wesson invited the society to be his guest at Savannah, Ga., at its winter meeting. Great cotton oil and naval store plants are located there, and not least of all, Savannah is the most typical of all southern towns.

Papers Presented

The major part of the program was assigned to the symposium on electric furnaces. Extracts from three of these papers are included below and selections from the others will be given in a future issue. The Institute semi-annual report will be published shortly giving the texts in full. The Growth and Development of the Manufacturing Plant of the Providence Gas Company by Mr. W. H. Russell will be given in three parts. Dr. Chas. L. Palmer gave a splendid review of the gaps left in the chemical study of the wool grease. The most amusing debate was precipitated by Dr. Edward Gudeman's argument that chemists should be licensed. Dr. James R. Withrow, who was scheduled to support the issue, sidestepped the matter and Drs. A. W. Smith and David Wesson went at the argument so vehemently that the old western proverb which said, "Never stop to argue with a Smith & Wesson" certainly proved to be as wise a maxim for oratorical combats as those fought with lead.

Symposium on Electric Furnaces

The program for the symposium was arranged by Mr. C. T. Bragg of the Michigan Smelting & Refining Co. The first paper was read by H. W. Gillett, of which the following are extracts:

Utilization of Electric Brass Furnaces

Four years ago there was no electric brass furnace in commercial operation. Today some forty firms are using or now installing approximately 100 electric brass furnaces. One rolling mill has about 30, though most of these are small 300-lb. furnaces. One smelting and refining company is using four one-ton and four three-quarter-ton furnaces. Another firm has four one-ton furnaces and the various offices of the U. S. Mint will soon have five furnaces. Batteries of two or three furnaces are quite common.

Five types of furnaces have advanced far enough so that the makers can cite truly commercial performances. Various other types are in the experimental or semi-commercial stage but are not yet on the market, and a few are on the market with some at least of the experimental troubles left for the purchaser. While recogniz-

ing that there is yet no perfect electric brass furnace, and that future development may produce a type superior to those now in commercial use, prospective users may properly pay first attention only to the types which have been commercially proven in users' hands.

These types are (1) Direct arc type, with the Snyder as the only make as yet really used on copper alloys out of the dozen of that type that are used for steel, (2) the vertical ring induction furnace type (Ajax Wyatt), (3) the granular resistor, reflected heat type Baily), (4) the stationary indirect arc type (Rennerfelt), and (5) the indirect ore type with stirring of the melt (rocking furnace). Clamer,[1] Baily,[2] vom Baur,[3] Miller,[4] the writer,[5] and especially St. John[6] have previously discussed the possibilities and limitations of these various types and a mere summary is sufficient here.

The Ajax-Wyatt is the most efficient in use of power, uses up no electrodes, gives thorough mixing of the charge, perfect temperature control, and has the steadiest electrical load. It must be "primed" with previously melted metal after a shut-down and hence is not well fitted for 10-hour operation, though it can be used on 10-hour operation by keeping some current on and holding some metal molten overnight. The need for "priming" makes it difficult to change from one alloy to another. It has been mainly used on yellow brass, though it is applicable to red. Its greatest drawback is that so far no refractory lining has been found that will satisfactorily withstand the action of alloys containing over 3 per cent lead. It is best fitted for 24-hour operation on the same alloy. It could be mechanically charged.

The Baily is the least efficient in use of power, does not mix the charge, but has a steady electrical load and uses up no electrodes. This type cannot be powered as high as others without grave danger to the resistor troughs, and is hence at a disadvantage as to efficient use of power, especially on alloys of high melting point. It is best fitted for 24-hour operation. When used for 10-hour operation it is usually necessary to put power on part of the night to keep the empty furnace hot. It is not readily charged mechanically. It has poor temperature control, due to its heat storage and consequent sluggishness. It can be used on any alloy but is better fitted for yellow brass than for the higher melting alloys. Its greatest advantage is its simplicity of operation.

The Snyder or any other direct arc furnace is applicable only to true bronzes or other alloys low in zinc, 5 per cent zinc being the probable limit. It is entirely impractical for use on alloys high in zinc. The only installation used for copper alloys is used on leaded bearing bronze, the new lead being added in the ladle. Much lead is volatilized from the scrap in the charge, and much fume results, giving bad working conditions. The installation of Snyder furnaces has a very poor power factor, though this is not necessary in a direct arc furnace.

The greatest advantage of the Snyder furnace in its limited field is its adaptability to mechanical charging, which aids in securing large output and hence in reasonable power consumption. One drawback is the single-phase arc load.

The Rennerfelt or any other stationary indirect arc furnace is most applicable to alloys low in zinc. It has been used on alloys up to 22 per cent zinc with fair results, but as the zinc increases above 10 per cent the metal losses increase, and 10 per cent zinc is probably the economical limit of its application. It has met with decided success in melting cupro-nickel, bronze and silver at the Mint. It is not readily charged by mechanical means. The power consumption is fairly low.

The rocking type of indirect arc furnace is applicable to alloys of any zinc content, gives a low power consumption, is apparently efficient in small as well as large sizes, can readily be mechanically charged, has good temperature control and mixes the charge thor-

[1]Clamer, G. H., Melting Brass in the Induction Furnace, *Journ.* Am. Inst. Metals, Vol. 11, 1917, p. 381.
[2]Baily, T. F., Resistance Type Furnace for Melting Brass, *Trans.* Am. Electrochem. Soc., Vol. 32, 1917, p. 155.
[3]Vom Baur, C. H., The Rennerfelt Electric Arc Furnace, *Trans.* Am. Electrochem. Soc., Vol. 29, 1916, p. 497.
[4]Miller, D. D., The Electric Furnace as a Medium for Heating Non-Ferrous Metals, *Journ.* Am. Inst. Metals, Vol. 11, 1917, p. 257; *Met. & Chem. Eng.*, Vol. XVII, No. 9, p. 537.
[5]Gillett, H. W., and Rhoads, A. E., A Rocking Electric Brass Furnace, *Journ.* Ind. Eng. Chem., Vol. 10, 1918, p. 459; *Met. & Chem. Eng.*, Vol. 18, No. 11, June 1, 1918. Melting Brass in a Rocking Electric Furnace, *Bull.* 171, U. S. Bur. Mines, 1918.
[6]St. John, H. M., The Present Status of Electric Brass Melting, *Chem. & Met. Eng.*, Vol. 19, 1918, p. 321.

TABLE I. PERFORMANCE OF ELECTRIC BRASS FURNACES

Name	Type	Power Supply Kw.	Charge Lb.	Power Factor	Material	Output-Tons per Day on Material 10-hr. Operation	Output-Tons per Day on Material Given 24-hr. Operation	Power Consumption Kw.-Hr. per Ton on Material and Time of Operation Given	Consumption of Graphite Electrodes Lb. per Ton
Ajax-Wyatt	Vertical ring induction	30	300	85	Yellow brass	1 to 1½	.....	300–350*	None
		30	300	85	Yellow brass	.....	3 to 3½	225–310	None
		60	600	72	Yellow brass	2½ to 3	.....	250–300*	None
		60	600	72	Yellow brass	.....	6 to 7	185–250	None
Baily	Granular resistor	105	800–1500	98–100	Yellow brass	2½ to 3½	.....	400–500*	None
		105	800–1500	98–100	Red brass	2½ to 3	.....	450–550*	None
		105	800–1500	98–100	Yellow brass	.....	6–10	275–350	None
		105	800–1500	98–100	Red brass	.....	6–9	325–400	None
Snyder	Direct arc	100	600	35–70	Leaded bearing bronze	1½	.....	380	—(Experimental test)
		300	2000	30–60	Leaded bearing bronze	.....	12–18	260–320	3–5
Rennerfelt	Indirect arc	100	500	75–90	Red brass	1½	.....	450–500	3–6
	Indirect arc	125	1000	75–90	Bronze	2 to 2½	.....	375–425	3–5
		125	1000	75–90	Bronze	.....	7–10	325–375	3–5
		300	2000	75–90	Leaded bearing bronze	.....	10–16	300–350	3–5
Rocking	Indirect arc	40	125	80–90	Red brass	¾	.....	400	—(Experimental)
		225	1300	80–90	Red brass	3½	.....	325–340	2½ to 4
		225	1300	80–90	Red brass	.....	8½	250–275	2½ to 4
		300	2000	80–90	Red brass	6 to 7	.....	275–325	2½ to 4
		300	2000	80–90	Red brass	.....	16–20	225–275	2½ to 4
		300	2000	80–90	Yellow brass	6 to 7	.....	250–300	2½ to 4
		300	2000	80–90	Yellow brass	.....	16–20	200–250	2½ to 4

* Including necessary night heating.

1 J. S. MILLER, JR.
2 O. R. QUAYLE
3 F. C. ZEISBERG
4 H. W. FOX
5 A. C. LANGMUIR
6 WALLACE SAVAGE
7 G. M. DAVIDSON
8 F. W. FRERICHS
9 F. M. DE BEERS
10 HENRY HOWARD
11 PAUL R. CROLL
12 B. R. TUNISON
13 W. C. BAINBRIDGE
14 GEO. C. PUCKHABER
15 WALTER B. MURPHY
16 A. H. KRAUSE

33 DAVID WESSON
34 MRS. DAVID WESSON
35 MRS. H. K. MOORE
36 MRS. A. C. LANGMUIR
37 MRS. GEO. M. DAVIDSON
38 MRS. F. M. DE BEERS
39 MISS RUTH LANGMUIR
40 MISS OTTILIE PROCHAZKA
41 MRS. B. R. TIMISON
42 MRS. HENRY HOWARD
43 HUGH K. MOORE
44 JOHN C. OLSEN, Secretary
45 MRS. JAMES MUNN
46 MRS. WALLACE SAVAGE
47 MRS. G. A. PROCHAZKA

oughly. Its drawbacks are the single-phase arc load and the possibility of electrode breakage in rocking too early if unskillfully operated.

The performance of the various furnaces properly operated may be expected to lie in the ranges set forth in Table I.

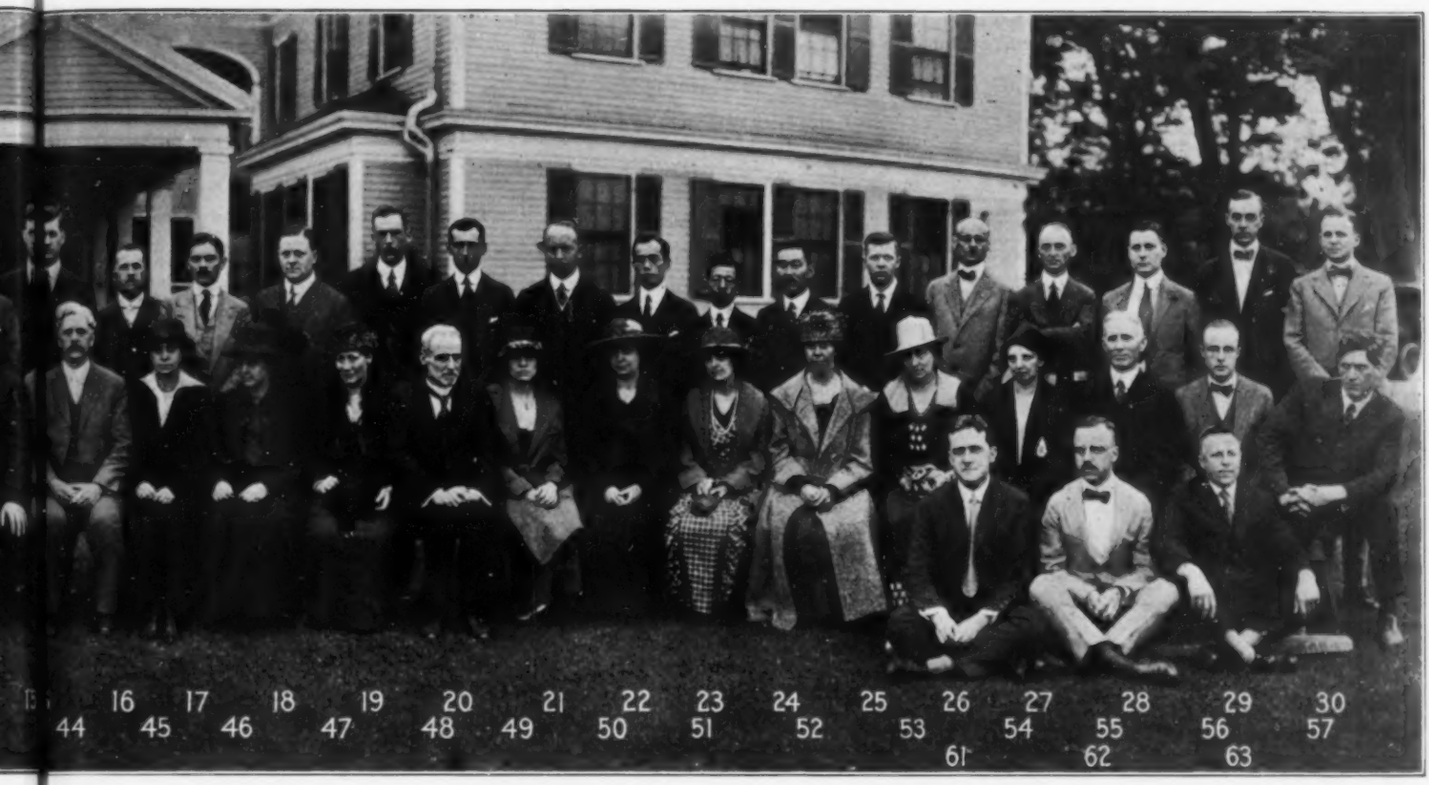
The figures in Table I do not in all cases agree with the catalog claims of the makers of the furnaces, as they are based on data obtained both from makers and users. The output and power consumption depend not only on the analysis of the charge, but also on the condition of it, i.e., whether all ingot, heavy scrap, light scrap, borings, or mixtures, as well as on the way the furnace is operated, just as gasoline consumption varies with the roads and the way the car is run. It will be noted that there is a wide variation in power consumption among the various types of furnaces, and that for the same type, the efficiency increases with the size.

If the types of furnaces unfit for use on alloys high in volatile metals are confined to use on alloys free from or sufficiently low in such metals, and if the furnaces are kept tightly closed after the charge is melted, all types of electric furnaces will give very low metal losses indeed. No fuel-fired furnaces can compete with properly chosen electric furnaces on this score. Of course, the lost metal is mainly zinc and lead, so that the value of the loss in fuel-fired furnaces is not as great as it would at first sight appear to be when the percentage loss is considered. This loss, however, usually amounts to about as much as the fuel or labor cost, and, even with cheap zinc and lead, is worth eliminating.

In making a choice of furnaces the user must first eliminate those types which will not operate satisfactorily on alloys he must melt in them, for example, the rolling mills making yellow brass would thus eliminate the direct arc and un-rocked indirect arc furnaces, and the makers of alloys high in lead and the people who must change from one alloy to another often would eliminate the Ajax-Wyatt. The user should then select from the remainder the type and size of furnace which will best fit his particular work. If he has very cheap power available, the granular resistor type may be chosen over a more efficient arc furnace because of the avoidance of electrode consumption. Where power is high, the balance would be against the granular resistor type. One rolling mill may prefer to continue to pour very small billets and may find the Ajax-Wyatt exactly suited to its needs. Another may wish to operate on a larger scale and may find a one-ton rocking furnace more suitable. A maker of bronze who must take his power from a very small power plant may find that a single-phase arc load would be unacceptable to the central station and hence might choose the two-phase Rennerfelt instead of the single-phase rocking furnace.

The size of furnace chosen will depend on the output desired and on whether 10- or 24-hour operation is called for. While the largest size furnace that can be kept busy should be used, it is poor economy to purchase a large furnace and then operate it with charges much under its capacity or to allow it to lie idle a good share of the time.

An electric furnace is expensive in first cost. The one or two furnaces required to melt 5 tons per day on ten-hour operation will cost from $10,000 to $20,000



17 W. ASEF
18 C. L. BRYDEN
19 WALTER M. RUSSELL
20 G. A. PROCHAZKA, JR.
21 G. L. OSTGREN
22 HANBEY SHIMIDZU
23 MASAMOTO INOUYE
24 YOSHIICHI TADA
25 P. E. KRAUSE
26 W. S. PUTNAM
27 C. D. CARPENTER
28 J. M. WEISS
29 H. L. SHERMAN
30 JAMES MUNN
31 A. M. BRECKLER
32 A. L. GARDNER

48 GEORGE A. PROCHAZKA
49 MRS. P. R. CROLL
50 MRS. JAMES BROWN
51 MRS. W. O. BAINBRIDGE
52 MRS. A. L. GARDNER
53 MRS. A. H. KRAUSE
54 MRS. W. O. QUAYLE
55 W. O. QUAYLE
56 P. S. BARNES
57 CHESTER G. GILBERT
58 R. L. DAVIDSON
59 H. S. DAVIDSON
60 ROBERT P. CALVERT
61 JAMES BROWN
62 STEPHEN L. TYLER
63 GEORGE P. HAHLWEG

completely installed. For purposes of calculation assume the cost to be $15,000. At 300 days per year the output is 1500 tons. Taking interest at 6 per cent, the interest is $900 per year or $3.00 per working day, this amount being lost every day the furnace is idle. At full output the interest charge is 60c. per ton.

On the other hand, if one furnace costing $10,000 is operated for 300 days per year 24 hours a day with an output of 16 tons, the total output is 4800 tons, and daily interest charge $2.00 per day, or 12½c. per ton.

On account of the initial cost and the interest charge, one should in general not have electric furnaces standing idle to handle small peaks of production in excess of the normal, but should utilize for this fuel-fired furnaces of lower initial cost.

On the other hand, the greater the number of electric furnaces which can be kept busy the lower the cost of power per ton.

Basis of Power Rates

Industrial power contracts usually have two factors, the demand charge and the energy charge. The first pays the power company for the equipment it must maintain to supply the maximum power needed, while the second depends on the total amount of power used.

Suppose we have a maximum demand of 300 kw. and that the average power consumption per ton of metal is 335 kw.-hr. per ton on 9-hour operation, 275 on 18-hour, and 250 on 24-hour. The total power used per day is then about 2000, 3565, or 5250 for the three cases. In a 25-day month this makes 50,000, 91,000 and 130,000 kw.-hr. per month.

Assume that the plant, before it installed its electric furnace equipment, had a maximum demand in lights and motors, of 200 kw., and used 20,000 kw.-hr. per month for those purposes. Taking a concrete case where the power contract calls for a demand charge of $1.80 per kw. per month for the first 50 kw. and $1.00 per kw. per month for all over 50 kw., and the energy charge schedule is

2500 kw.-hr. per month at 2.0c. per kw.-hr.
for the next 35,000 kw.-hr. per month at 0.8c. per kw.-hr.
for the next 310,000 kw.-hr. per month at 0.5c. per kw.-hr.
all over 347,500 kw.-hr. per month at 0.4c. per kw.-hr.

The 200 kw.-20,000 kw.-hr. lighting and motor power cost

50 × $1.50 = $75.00	2,500 × 2.0c. = $50.00
150 × 1.00 = 150.00	17,500 × 0.8c. = 140.00
$225.00 demand	$190.00 energy charge

Total $415.00 or 2.07½c. per kw.-hr. used.

The plant now has 500 kw.-hr. maximum demand, and 70,000, 111,000, 150,000 kw.-hr. used per month on the three assumptions.

50 × $1.50 = $75.00
450 × 1.00 = 450.00
$525.00 demand

Energy—case 1—2,500 × 2.0 = $50.00
35,000 × 0.8 = 280.00
32,500 × 0.5 = 162.50

70,000 $492.50 energy
525.00 demand

$1017.50 total charge
less 415.00 previous charge for lights and motors

$602.50 total charge for electric furnace power

$$\frac{602.50}{70,000} = 0.860$$

The electric furnace costs 0.860 c. per kw.-hr.

In case 2 we have the same demand charge, but the energy charge is

2,500×2.0=	$50.00
35,000×0.8=	280.00
73,500×0.5=	367.50
111,000	$697.50 energy
	525.00 demand
	$1222.50 total
less	415.00 lights and motors
	$807.50 total charge for furnace power

$$\frac{807.50}{91{,}000} = 0.89$$

The furnace power costs 0.89c. per kw.-hr.

In case 3 we have

2,500×2.0=	$50.00
35,000×0.8=	280.00
112,500×0.5=	562.50
	$892.50 energy
	525.00 demand
	$1417.50 total
less	415.00 lights and motors
	$1002.50 total charge for furnace power

$$\frac{1{,}002.50}{130{,}000} = 0.79c$$

The furnace power costs 0.79c. per kw.-hr.

And, if in case 4 the plant had three times the furnace installation figured above and used it 24 hours a day, or 900 kw. furnace demand 1100 kw. total, 450,000 kw.-hr. per month furnace energy, 470,000 total, the charge would figure

50×1.50	75.00	$2370.00 energy
1050×1.00	1050.00	1125.00
	$1125.00 demand	$3495.00 total
		less 415.00 lights, motors
25.00×2.0=	$50.00	$3080.00 total for furnace power
35.000×0.8=	280.00	3,080.00
310.000×0.5=	1550.00	$\frac{3{,}080.00}{450{,}000} = 0.685c.$
122.500×0.4=	490.00	450,000
	$2370.00 energy	The electric furnace power costs 0.685c. per kw.-hr.

Tabulating these we get Table II.

TABLE II.

Case	1	2	3	4
Hours	9	18	24	24
No. furnaces	1	1	1	3
Kw.-hr. per ton	335	275	250	250
Power price per kw.-hr	.860	0.89c.	0.79c.	0.685c.
Cost per ton for power	$3.92	$2.45	$1.98	$1.71

This table shows the advantage of continuous operation of electric furnaces, as well as that of large installations. The exact figures will vary in each particular case, but the ratios will remain approximately the same.

The elimination of delays will give a 25 per cent increase in output in an hour's less time, and decreases the cost of power per ton by about 40c.

The cost of power is in most cases the largest single item in melting costs in electric-furnace practice. Every effort must then be put forth to keep this cost down. The way to do this is to keep the furnace at work at its job, which is melting metal. This is important on 24-hour operation, but even more so on 8- to 10-hour operation, for an extra heat per day on single-shift operation means that it is obtained at the end of the day when the furnace has recovered from cooling off through the night. Any furnace will illustrate this fact. Take an actual day's run of a small Rennerfelt on red brass for example.

Heat	Charge Lb.	Total Time	Arc On	Idle Time	Kw.-Hr. Used	Kw.-Hr. per 100 Lb.	Notes
1	497	2:45	2:05	40	211	42	Furnace at red heat from previous day's run.
2	522	1:45	1:25	20	130	25	
3	527	2:55	1:10	1:45	105	20	Delay waiting for molds.
4	523	1:25	1:05	20	106	20	
5	394	1:25	1:10	15	94	25	Waiting for molds, so held power input low.
	2,463	10:15	6:55	3:20	646	26	Av. or 520 kw.-hr. per ton

This could have been run as follows, by eliminating all delays:

Heat	Charge, Lb.	Total Time	Arc On	Idle Time Charging and Pouring	Kw.-Hr.	Kw.-Hr. per 100 Lb.
1	525	2:10	1:55	10	215	41
2	525	1:40	1:25	15	130	25
3	525	1:25	1:10	15	105	20
4	525	1:20	1:05	15	100	19
5	525	1:20	1:05	15	100	19
6	525	1:20	1:05	15	100	19
	3,150	9:15	7:45	1:30	750	24 av. or 480 per ton

With the exception of the granular resistor type in which it is difficult to hold metal after it is once ready to pour because the response to changes in power input is so slow, it is possible to hold metal ready to pour as long as one likes in any of the electric furnaces. This is a convenience in an emergency, but it is very poor practice from the point of view of furnace efficiency.

In addition to using efficient discharging and charging devices, another way that power can be saved in electric melting is to operate on a definite schedule of power used. The Ajax-Wyatt takes power at so steady a rate that a time schedule works just as well on that type, but the granular resistor furnace and the arc furnaces may vary considerably in rate of power input. After a few test runs, one can, for any particular alloy, particular proportion of ingot, scrap and borings, and for any particular weight of charge, make out a perfectly definite schedule of kw.-hr. needed on each heat. In 10-hour operation the kw.-hr. per heat will be higher in the morning and approach or reach a lower constant figure at the end of the day.

By adhering to such a schedule and running on kw.-hr. input instead of on a time schedule at a supposedly constant but actually variable kw. input, the heat can be brought out with astonishing regularity as to temperature. Each furnace should have its individual kw.-hr. meter, and one readable to certainly not less than 5 kw.-hr., and better 1 kw.-hr. With individual kw.-hr. meters the performance of each furnace in a battery, and of each furnace tender can be watched.

Inasmuch as the heat losses through the walls and the electrodes are approximately constant even though the rate of power input may change, it is obvious that the higher the rate of power input, the more of it is usefully employed in melting. Suppose a furnace takes 100 kw. and loses 35 kw. through shell radiation and electrode losses, 65 kw.-hr. then do useful work. If the same furnace is given 125 kw. it may lose 37½ kw. in shell and electrode losses, but 87½ kw. do useful work. The furnace will do one-third more work in a given time at the higher rate. The upper limit of rate of input is that at which the local temperature is so high that refractories fail or that local overheating of the metal and consequent loss of volatile metals ocur. It is quite probable that on the larger furnaces automatic control of power input would be desirable.

Electric Furnaces of the Resistance Type

Mr. T. E. Bailey illustrated his paper with moving pictures. The following are selections from his paper:

The principal factors taken into consideration as necessary to the development of a successful brass melting furnace were (1) the metallurgical requirements (2) the mechanical features (3) the electrical characteristics (4) the thermal efficiency (5) the commercial economy as compared with other types of melting equipment.

The obvious advantages to be found in an ideal electric furnace over fuel fired types for melting were (1) the elimination of crucibles, which are one of the principal costs in the melting of brass in pit type furnaces (2) the reduction in metal loss when handling zinc mixtures, on account of the slight vacuum under which all pit type furnaces are required to operate (3) the inability to maintain a reducing atmosphere in the furnace when operating with any degree of fuel efficiency, and (4) the fact that copper alloys, as well as copper, have a high affinity for the absorption of undesirable gases when in their molten condition, this being equally true of other alloys and non ferrous metals, such as aluminum.

Before the development of these furnaces for brass melting, a careful survey was made as to the adaptability of the more common types of furnaces then widely in use in the melting of steel, to determine whether such furnaces could be readily and successfully adapted for brass and other non ferrous melting operations; and if they could be, with what degree of commercial efficiency, as compared with the resistance type of furnace we then had under consideration.

When considering the use of the true resistance type furnace as it might be applied to the melting of non ferrous metals, the following points were given consideration

(1) That the metal should be contained on a true open hearth, and that the heating element should be entirely independent of the metal.

(2) That the heating element should be such that there would be a comparatively slight difference in temperature between this heating element and the bath, so as to overcome the objectionable features offered by the arc type furnace.

(3) That it should be feasible to tightly close the furnace in order to keep the molten metal under a pressure, however slight, and to prevent, as well, any draft of air through the furnace chamber.

(4) That the electrical characteristics of the furnace as applied to power factor should be such as to overcome the objections present in the induction furnace, and that the wide power variation present in the arc furnace should be, if possible, eliminated.

(5) That the furnace should not be subject to rapid changes in temperature from the most desirable ruling temperature for any particular melting operation.

(6) That the furnace should be as compact as possible, in order to reduce radiation losses to a minimum.

In this latter case, while the resistance type furnaces about to be described require a somewhat larger shell for a given melting capacity than either the arc or induction furnace, the absence of the highly localized temperature does not produce such a serious condition with regard to refractories; and the lower temperature with which the resistance element in a resistance type furnace operates, enables a higher degree of heat insulation to be used, so that the thermal efficiency of resistance type furnaces compares favorably with other types—with the exception, perhaps, of the induction furnace, whose higher thermal efficiency is seriously offset by its higher renewal and repair cost.

One of the mechanical features taken into consideration before determining on the type of furnace to be used was whether it was necessary, in order to obtain perfect alloying, to provide some oscillating motion, such as was originally used on the Stassano stool furnace; but when considering that substantially all copper alloys, with the exception perhaps of lead, diffuse completely when the proper temperature and melting conditions are reached, this additional complication was dispensed with, the only agitation required being the stirring in of the spelter previous to pouring, and this stirring is only required in order to facilitate the more rapid diffusion of the alloy.

The only materials in the furnace described in this paper that need regular renewal are

(1) the resistor troughs themselves, which are made of carborundum, fire sand and water glass, and were formerly tamped into place in the furnace with the aid of wooden forms, but are now made in sections at our works and baked ready for placing into the furnaces;

(2) the electrodes for leading the current from the cable terminals through the furnace walls and into the resistor material;

(3) the resistor material itself, which consists of broken carbon crushed to about ¼" mesh.

Under average working conditions, the fire sand troughs, and a pair of electrodes will last from three to four months, while the resistor material requires additions to it of fresh material every two weeks. This latter is accomplished in the small tilting furnace by raising the roof through the medium of three screws which are operated simultaneously by a hand wheel on the back of the furnace operated through sprockets and mitre gearing.

Some months ago for a period of time, some difficulty was experienced with resistor troughs, but a careful and exhaustive investigation brought to light that this trouble was experienced only when the analysis of the fire sand indicated an imperfect mix; and since all this material must now pass laboratory inspection, no difficulty is experienced from this source.

The furnaces now to be described are built in two regular types, the first, which has found wide applications in foundries, is of the round tilting type; while the other, of rectangular shape, is the type used for melting large tonnages and for smelting operations.

The round type is provided with a circular resistor trough with the electrodes coming into the trough diametrically opposite each other, the resistor material being renewed by lifting the roof, as previously stated; while in the rectangular type, the resistor troughs are two in number and placed longitudinally along each side of the hearth, and are, therefore, straight. The resistor material, in this case, is charged by means of long shovels through a door at each end of the furnace and directly above the trough. This furnace is a standard 105 K.W. trunion type with a rated hearth capacity of 1500 pounds and a melting rate of 600 pounds per hour. These capacities, however, have been in numerous cases materially exceeded, as much as 2 tons having been placed in a furnace at a time, and the melting rate increased to more than 1000 pounds per hour, when operating under exceptionally favorable conditions.

This furnace consists of a steel shell made of ½" plate seven feet in diameter and approximately 6′ high, mounted on the usual cast iron trunions and brackets, and having the usual hand wheel tilting mechanism.

The interior wall of the furnace is substantially 5½" in diameter, with a wall of circular brick about 4½" thick. The space between the brick wall and the steel shell is filled with kieselguhr insulation. The steel roof ring is adopted to hold securely the skew backs of the domed arch, and is provided with a lower fin for dipping into the sand seal. The space above the trough dome and below the steel top is also filled with kieselguhr in the same manner as between the fire brick walls and the steel shell of the furnace proper.

The hearth is located in the bottom of the furnace and is composed of a mixture of carborundum fire sand and plastic clay material bonded with silicate of soda. The resistor trough is located above the bath and completely encircles the rim of the hearth line, although located a considerable distance above it, and is set on fire brick piers, so that the heat from the lower part of the fire sand trough is readily dissipated from this part of the trough within the furnace chamber.

This feature is of vital importance in the successful design and operation of resistance type furnaces, as all early experiments with furnaces of this type without this feature resulted in failure.

The resistor material contained in this trough, and into which the electricity is introduced by means of the two carbon electrodes, as previously mentioned, radiates the heat generated in it to the roof of the furnace and thence down onto the hearth; while the heat coming from the lower part of the trough between the supporting pillars, is also radiated directly to the bath. That this resistor ring has a radiating surface of over forty square feet accounts for the fact that there is no highly localized temperature in this furnace.

The control of the furnace is obtained by means of impressing the various voltages on the low tension side of a special transformer across the furnace terminals by means of a special selective oil break switch. The special transformer supplied with each furnace is wound for any convenient line voltage, while the secondary of the transformer is provided with various voltage taps, usually giving a voltage ratio of two to one on the low tension side. By means of this arrangement, the electrical losses are reduced to a minimum, and an accuracy of control obtained that is not possible by other types of equipment, and it is readily possible to operate over long periods of time without a greater variation in electrical input than a few per cent.

The only opening to the furnace, which is used for charging the material is provided with a swing type plug door, the hinges being made of cast steel and attached to the furnace shell in a rugged manner. The pouring spout is a groove underneath the door, which enables the molten material to be poured without opening the door, the door itself being opened only during the charging or rabbling time. A false door, consisting of a ribbed cast iron plate, is also provided, so that when the main plug type door is open during the charging or rabbling operations, this false door can be dropped down, shielding the operator from the direct heat of the furnace interior.

This 7′ diameter furnace is also built in a nose tilting type, and is operated by means of a motor driven screw mechanism at the rear of the furnace. In this type of equipment the charging door is placed at the rear and a small opening arranged at the front for pouring the molten metal. This is a type of equipment that is particularly well adapted for pouring directly into molds, and is especially well adapted to casting rolling mill slabs, when used in connection with a rotary casting table.

The casting table is adapted for a vertical adjustment of 40" for taking care of molds of different heights, and its turning motion is imparted by means of a motor driven vertical pinion engaging a circular rack attached to the movable table, the molds being attached to the top of the table in the usual manner.

The furnace is provided with a single resistor trough located directly above the bath, with the electrodes entering at the side. This type furnace is particularly well adapted to the smaller foundries or plants where a wide variety of mixtures are handled in relatively small quantities. The electrical characteristics of this furnace are similar to those of the furnaces just described.

Of the stationary non-tilting furnaces referred to in the fore part of this paper, the smaller size is of 500 K. W. capacity, and is adapted to hold 10 tons of brass or 3 tons of aluminum. This furnace has a resistor trough of the usual type located at each side of the bath, which is supported on the usual fire brick pillars. The doors in this case are located at each end of the furnace and are of the sand sealed type.

The furnaces described in this paper are the results of years of experience, first in the development and operation of furnaces for the annealing and heat treating of steel, and later a wide experience over the last several years in furnaces built especially for the melting of brass and other non-ferrous alloys, which it is believed will find a wide application throughout the non-ferrous industry, not only in brass foundries and rolling mills, but also in melting and refining in smelters. This is particularly true of the furnace described for melting cathode inc, which it is believed will find a wide application in the melting of cathode copper, which latter operation has been accomplished in furnaces of this type without the usual blowing and poling necessary in refining; and producing copper wire bar or ingot of substantially the same analysis as the copper cathode, the finished bar or billet, having only that amount of sulphur contained on the cathode as charged and coming from the electrolyte.

As an example of what may be accomplished and of the comparative amounts of sulphur contained on the edges of the cathode sheets as compared with the center, a quantity of copper cathode was obtained and the edges of the sheet to a depth of about 2 in. sheared off. This material was melted in one of our standard 105 K.W. furnaces and cast into pig. The analysis of the bars so cast is shown in Table A below, while the result from the melting of the inner part of the sheet are shown in Table B.

TABLE A

Analysis:

99.904 Cu.	.084 O.	.0021 S.	Conductivity 100.1

TABLE B

99.950 Cu.	.036 O	.0012 S	Conductivity 100.8

In the remelting of clean scrap, wire and similar substantially pure copper materials, it is found that this clean scrap can be remelted without any deterioration in the quality whatever, and furnaces of the character described in this paper will undoubtedly shortly come into general use for not only the melting of copper cathodes, but for the remelting of rolling mill scrap as well.

In the development of these melting furnaces constant attention has been paid to such features as were

deemed necessary for the production of equipment that could operate over long periods of time without shut down, having good electrical characteristics, convenient and accurate control of both the metallurgical and thermal characteristics, and which could at all times operate under reasonably high efficiency, but no attempt has been made to sacrifice the qualities of ruggedness of design and reliability of operation to the mere consideration of current consumption under test conditions.

Rocking Electric Arc Furnace

Mr. H. M. St. John reviewed the factors involved and then showed how this type of furnace fitted them as follows:

The rocking electric furnace consists essentially of a cylindrical steel shell, lined with suitable refractories, and mounted on rollers and ring gears which permit it to be rocked through any desired arc of revolution up to a maximum of 200 deg. This rocking motion is actuated by a small induction motor through a reducing gear immersed in oil and enclosed in a tight gear case. The action of the motor is controlled by an automatic reversing switch which may readily be set to give the desired angle of rock. The source of heat is an electric arc between horizontal graphite eelctrodes axially placed in the furnace and meeting at the center of the cylindrical melting chamber. These electrodes are controlled by hand wheels which permit them to be entirely withdrawn from the furnace chamber when so desired. One of these electrodes is set in such a way as to locate the arc approximately at the center of the furnace and is thereafter allowed to remain stationary, while the operator controls the arc by adjustment of the other electrode.

During charging the electrodes are withdrawn until their tips are flush with the inner wall of the furnace in order to avoid striking them with heavy pieces of metal which might cause breakage. The furnace is then closed, the electrodes brought to the operating position, and the arc started. During the first few minutes of the melting period the furnace is not rocking, since rocking at this stage is unnecessary and might cause electrode breakage if started prematurely. As the metal becomes soft, rocking is started, through a small angle at first and reaching a maximum rock as the metal becomes completely molten and enters the superheating stage. During this complete rock the molten metal washes the inner lining of the furnace to within a few inches of the charging door at either end of the oscillation, at the rate of approximately two complete oscillations per minute.

When the charge is molten, it lies in the lower half of the furnace cylinder at a distance of from seven to ten inches from the arc. The metal is heated by conduction from the entire refractory lining as well as by direct radiation from the arc. The stirring action due to the constant rocking motion of the furnace is sufficiently effective to maintain a constant temperature throughout the melt and thus prevent the surface overheating which would result if the furnace were stationary.

When the melt has reached the desired pouring temperature, the arc is broken and the metal is poured through the spout beneath the charging door. The door itself is not opened until the furnace is ready to charge. If, for any reason, it is impossible to pour the metal immediately, the charge may be held in the furnace without danger of overheating, since no part of the furnace structure is appreciably hotter than the metal. If desired, rocking may be continued during this period, in order to insure a perfectly uniform temperature and a thorough mixture of the alloying metals.

The indirect arc lends itself excellently to the maintenance of a uniform power input and a steady electrical load. After a little experience the operator learns to judge from the kilowatt-hour input, how to adjust the rocking of the furnace and when the metal is hot enough to pour. In other words, he knows what condition the metal is in by observing from his meter how many kilowatt-hours of heat he has put into the furnace. This is the most convenient and satisfactory method of controlling the temperature, as well as the heat input, and works extremely well, even with an operator of very mediocre intelligence.

The reliability of the furnace is high, since its construction is both simple and rugged. Its cylindrical form permits the strongest possible refractory structure; the method of heat generation is simple and involves no complicated parts, electrical or otherwise; the gears and other parts of the rocking mechanism are sturdy and not exposed to high temperatures, while the electrical control mechanism is as simple as it can be made and very seldom a source of trouble. There is nothing complicated about the controls and even the greenest of operators rapidly becomes proficient in their use.

The power imput of the furnace is relatively large and its thermal efficiency high, this desirable combination resulting in a high productive capacity. The arc is not more than ten inches from the metal on a full charge, while it is approximately eighteen inches distant from the nearest refractories—the vertical and walls—and 20 inches from the cylindrical walls. This makes possible a rapid rate of heating without injury to the refractories, while overheating of the surface layer of the metal nearest to the arc is prevented by the constant mixing which it undergoes. Using 2000 lb. charges, the rocking furnace will produce approximately 2000 lb. of molten brass per hour, melting time, or about 1500 lb. per hour, elapsed time, the latter including time consumed in charging, pouring, and incidental delays. This is a higher productive capacity than can be obtained with any other electrical brass-melting furnace of similar size.

The quality of the metal produced is a function of temperature control, thorough mixing, and the absence of impurities. Any electric furnace which does not burn the metal makes possible the avoidance of impurities and thus compare favorably with fuel-fired furnaces, which expose the metal to a rapidly moving oxidizing atmosphere which also contains sulphur and other undesirable products of combustion.

Accurate temperature control is difficult in those types of electric furnaces which heat their refractory walls and roofs far above the metal temperatures, thus causing the metal to absorb heat even after the electric curent has been turned off. In an arc furnace the heat input stops immediately when the switch is opened and metal can be held in the furnace indefinitely without danger of overheating.

In the rocking furnace a perfect mixture of the metals which go to make up the alloy can readily be attained, by virtue of the brisk agitation which the molten metal receives. Even high-lead alloys can be poured

from the furnace in perfectly homogeneous mixtures. The table below shows the results obtained with a series of heats, from which samples were taken of the first ingot from the first ladle and the last ingot from the last ladle in each case. The variation in composition from heat to heat was due to the selective absorption of lead by a green furnace lining. While the variation in lead content between the first and last ingots of any heat is very small it will be noted that, in three cases out of four, the percentage of lead in the first ingot is higher than that in the last.

TABLE I.

Heat No.	Ladle No.	Per Cent Cu	Per Cent Sn	Per Cent Sb	Per Cent Pb	Per Cent Zn Plus Impurities
1	First	72.73	4.97	0.61	21.02	0.67
1	Last	72.12	4.88	0.61	20.97	1.42
2	First	68.89	4.86	0.61	23.19	2.45
2	Last	69.09	4.47	0.61	22.96	2.87
3	First	66.51	4.24	0.61	25.49	3.15
3	Last	67.15	4.30	0.61	25.28	2.66
4	First	67.07	4.30	0.61	25.02	3.00
4	Last	66.01	4.47	0.61	25.67	3.04

It is, of course, frequently very important to duplicate a complex alloy, for heat after heat, with a minimum deviation from the specified composition. Table II shows how exactly this can be done with the rocking furnace. The figures given in the table are taken, not from a special test, but from the routine analysis for thirteen consecutive heats from a rocking furnace melting phosphor bronze.

TABLE II.

Heat No.	Per Cent Cu	Per Cent Sn	Per Cent Pb	Per Cent Zn	Per Cent P
45	86.90	8.35	1.63	3.04	0.015
46	87.18	8.43	1.09	3.28	0.020
47	86.68	8.37	1.37	3.56	0.020
48	87.24	8.36	1.26	3.10	0.020
49	86.84	8.20	1.21	3.73	0.014
50	86.94	8.10	1.04	3.91	0.014
52	87.80	7.64	1.36	3.20	0.020
53	87.16	8.27	1.30	3.26	0.014
54	86.96	8.27	1.33	3.43	0.010
55	96.82	7.98	1.21	3.96	0.025
56	87.20	8.27	1.25	3.27	0.014
57	87.12	8.27	1.23	3.36	0.016
58	86.80	8.59	1.21	3.39	0.013
Average	87.05	8.24	1.27	3.42	0.017
Max. deviation from average...	0.75	0.60	0.36	0.54	0.008
Average deviation from average...	0.22	0.26	0.10	0.23	0.004

The thermal efficiency of the rocking furnace is high, and the energy consumption per ton of metal melted is correspondingly low. The thermal efficiency of the furnace is considerably higher than that of any stationary type of indirect-arc furnace, even higher than that of the direct-arc furnace. It is more nearly comparable to the efficiency of the induction furnace which, since the source of its heat is in the resistance of the metal itself, does not heat its refractories to a temperature higher than that of the metal and consequently enjoys the advantage of minimum radiation losses, as well as an utter absence of electrode heat losses. The high efficiency of the rocking furnace is primarily due to the fact that approximately four-fifths of the inner refractory lining is washed by molten metal, due to the rocking action of the furnace. Most of that part of the lining which is exposed to direct radiation of heat from the arc, and thereby becomes hotter than the metal, is intermittently brought into contact with the latter and gives up its excess heat to the metal instead of expending it uselessly through the outer walls. The furnace refractories are thus subjected to a constant cooling action and are maintained at a relatively low temperature, with the result that radiation losses are a minimum, appreciably lower than would be the case if the furnace were operated in a stationary position.

The comparatively low refractory temperature in the rocking furnace makes it possible to obtain a high thermal efficiency without an excessive thickness of heat-insulating wall. As a result, the temperature lag of the furnace is moderate and, when operating from 8 to 10 hours per day, the furnace reaches its maximum efficiency on the third heat of the day, an important consideration in intermittent electric furnace operation.

The number of kilowatt hours required per ton of metal varies widely, depending upon operating conditions and upon the nature of the alloy melted. One large rolling mill, operating the furnace 16 hours per day of 60-40 brass, gets a minimum consumption of less than 200 kw.-hrs. per ton and has averaged 224 kw.-hrs. over a total of several hundred heats. Average 8 to 10 hour operation on clean scrap and new metal mixture shows about 250 kw.-hrs. for yellow alloys, and 275 kw.-hrs. for red alloys. If a high proportion —over 50 per cent—of very oily or wet borings and grindings are included in the charge, the energy consumption on 2000 lb. charges may run as high as 300 kw.-hrs. per ton.

The ability to handle very dirty borings and fine scrap of all kinds, whether red or yellow, is an advantage peculiar to the rocking furnace. It is possible in this furnace to melt satisfactorily a charge consisting wholly of dirty yellow borings and grindings, without opening the furnace after melting begins, something which can hardly be done in any other furnace without mechanical rabbling accompanied by high metal loss.

Although as already mentioned, the labor cost per furnace-day with furnaces of similar size does not vary greatly from one electric furnace to another, the high productive capacity of the rocking furnace makes possible a very low labor cost per ton of metal melted.

The importance of the metal saving effected by any properly designed and correctly operated electric furnace is well recognized. In the rocking furnace clean yellow brass can be melted with a net loss below one per cent. With red mixtures the net loss is, of course, less than with yellow metal, usually not above 0.5 per cent. Borings and fine dirty scrap can be melted with far less loss than is the case in any type of fuel-fired furnace, or in any type of electric furnace where mechanical rabbling is necessary, although the loss is, of course, higher than with clean scrap or new metal mixtures. Metal losses under two per cent when melting very dirty borings and cuttings are by no means unusual, this with metal which must ordinarily be melted in a reverberatory furnace, with complete loss of the volatile constituents of the alloy. Red borings, if not too dirty, can be melted with a loss practically as low as that experienced with clean red scrap or new metal.

The rocking furnace has introduced one decided innovation in brass foundry practice. With this furnace it is not only possible, but even highly desirable, to add spelter with the rest of the charge at the beginning of the heat, when melting new metal or making up a deficiency of zinc in a scrap charge. This not only saves the time ordinarily consumed by the speltering operation but also avoids the necessity of opening the

furnace for this purpose, with the attendant loss of metal and heat. Tin and lead should also be added with the rest of the charge rather than at the end of the heat.

The excellent showing made by the rocking furnace, as compared with other types of arc furnaces, with respect to metal loss, is due to the rocking motion of the furnace, with the resultant agitation of the metal which eliminates all danger of local overheating of the charge.

The rocking feature of the furnace also plays an important part in prolonging the useful life of the refractory furnace lining. The continual washing to which most of the lining is subjected cools the refractories to a temperature only slightly above that of the metal itself, well below the critical temperature of the refractory brick used. The brick selected for this service is of such a nature that erosion by the constantly moving metal is not a serious factor. A single lining of corundite brick lasts for about 350 heats in average practice, at which time it requires more or less extensive patching. Under normal conditions it is never necessary to entirely replace this inner lining, while the intermediate and outer linings ordinarily require no attention. One user of the furnace reports having obtained 600 heats from his first lining, on intermittent operation, and states that he expects to obtain from 900 to 1100 heats on continuous operation. Under average conditions the refractory cost is less than $0.50 per ton of metal melted.

The electrode consumption is from 2 to 3 lb. per ton of metal melted, or, at present prices, from $0.50 to $0.75 per ton of metal. This compares very favorably with the best arc furnace practice in such installations as use the stationary type of arc furnace for melting copper alloys.

The overhead cost of melting with the rocking furnace is low, particularly in such installations as take full advantage of its inherently high productive capacity. The first cost of any electric furnace is rather high and the canny user will see to it that the furnace is busy melting metal for as many hours in each day as his manufacturing schedule will permit.

One more point which is of particular interest for the central-station company and others who supply power for electric furnace use: The electrical characteristics of the rocking furnace are such as to cause the furnace to be considered a highly desirable power load. As compared with arc furnaces in use for steel melting, its demand is exceptionally steady and free from violent fluctuations, while its average power factor is from 85 to 95 per cent. Its maximum demand is less than 300 kw. and the load which it imposes on the power line is so steady as to result in little or no inconvenience to the average central-station company or to those of its customers who may take power from the same line.

Cohune Nut Industry

In the search for materials suitable for the manufacture of gas-mask charcoal, the War Department found that the cohune (or corozo) nut, which yields a charcoal of high absorptive power, could be obtained in large quantities from Hondures. It was also discovered that the kernel of this nut contains an oil which is said to be superior to cocoanut oil and finds a ready sale as a high-grade cooking oil.

Attention is directed in Commerce Reports, June 6, 1919, p. 1230, to the fact that the extensive field of these nut-bearing trees found in the Aguan River Valley in Honduras is capable of yielding 10,000 tons of nuts a month, with a working force of 500 men.

It must be remembered that, if we desire to secure a permanent market for our products in South and Central America, we must, in turn, endeavor to utilize more of the raw materials which these countries have to offer and thus aid in the development of their natural resources.

Imports and Exports

The Bureau of Foreign and Domestic Commerce of the Department of Commerce, reports for April, 1919.

IMPORTS OF GLYCERIN (TOTALS) INTO U. S. AND DOMESTIC EXPORTS FROM U. S. BY COUNTRIES

Imports	Lb.	Value
Glycerin	34,345	$3,749

Exports of Glycerin Countries:	Lb.	Value
Greece	425	$219
Norway	1,120	250
Portugal	500	113
Spain	2,200	550
British Honduras	5	2
Canada	1,781	319
Costa Rica	700	175
Guatemala	961	482
Honduras	152	47
Nicaragua	238	103
Panama	47	29
Salvador	700	154
Mexico	3,400	837
Barbados	75	21
Jamaica	30	6
Trinidad and Tobago	150	36
Other British West Indies	7	2
Cuba	10,814	2,980
Dutch West Indies	23	11
French West Indies	7	4
Haiti	109	31
Dominican Republic	529	157
Bolivia	100	23
Brazil	3,954	867
Chile	11,139	2,994
Colombia	611	295
Ecuador	670	170
Peru	3,212	948
Venezuela	1,559	528
China	2,710	637
British India	2,404	994
Japan	186,560	31,868
New Zealand	55	23
German Oceania	10	8
Philippine Islands	650	167
Total	237,607	$46,050

DOMESTIC EXPORTS OF TIN PLATE, TERNE PLATE AND TAGGERS TIN FROM U. S. TO ALL COUNTRIES

Tin Plate, Terne Plate and Taggers Tin

Countries	Lb.	Value
Belgium	166,667	$21,205
Denmark	168,760	19,605
Greece	3,920	400
Iceland and Faroe Islands	5,350	430
Norway	662,630	50,451
Portugal	671,392	67,022
Spain	373,988	37,927
Sweden	480,524	38,257
Switzerland	461,820	48,330
Canada	9,496,288	709,301
Guatemala	6,196	587
Panama	22,174	1,581
Salvador	9,000	900
Mexico	1,234,445	96,216
Jamaica	22,456	1,835
Trinidad and Tobago	10,423	940
Cuba	216,623	21,175
French West Indies	10,315	900
Haiti	2,000	170
Dominican Republic	1,996	155
Argentina	4,727,265	425,149
Brazil	3,656,751	295,225
Chile	59,574	5,309
Colombia	6,493	707
Ecuador	5,500	600
British Guiana	1,675	205
Paraguay	91,014	7,336
Peru	210,582	14,688
Uruguay	2,782,186	236,634
Venezuela	76,254	5,809
China	861,521	94,944
Japanese China	78,483	6,560
British India	1,059,180	84,361
Dutch East Indies	160,000	16,000
Hong Kong	176,000	17,780
Japan	4,063,942	372,823
Turkey in Asia	682,800	48,514
New Zealand	50,318	2,472
Philippine Islands	8,250	610
British West Africa	2,140	162
Total	32,786,895	$2,753,275

IMPORTS OF TUNGSTEN-BEARING ORE INTO U. S. FROM ALL COUNTRIES—EXPORTS OF TUNGSTEN AND FERROTUNGSTEN METAL FROM U. S. TO ALL COUNTRIES

Imports Countries	Tungsten-Bearing Ore Tons	Value
Canada	18	$12,750
Chile	35	48,121
Peru	56	40,669
China	25	11,474
Kong Kong	180	192,899
Total	314	$305,913

Exports Countries	Tungsten and Ferrotungsten Lb.	Value
Sweden	3,300	$5,250
Canada	2,065	2,686
Total	5,365	$7,936

IMPORTS OF TIN BARS, BLOCKS, PIGS OR GRAIN OR GRANULATED INTO U. S. BY COUNTRIES AND DISTRICTS—TOTAL IMPORTS OF TIN ORE

	Tons	Value
Tin ore	534	$311,467

TIN BARS, BLOCKS, PIGS, GRAIN OR GRANULATED

Districts:	Lb.	Value
Massachusetts	112,040	$77,220
New York	56,000	42,641
Pittsburgh	56,000	44,114
San Francisco	1,026	650
Washington	55,716	$37,435
Chicago	224,121	135,141
Total	504,903	$337,201

Countries:	Lb.	Value
Straits Settlements	504,903	$337,201

The Present Status of Labor in the English Chemical Industry

By A. E. Marshall

IN PRE-WAR days in England, labor costs in the production of any of the staple chemicals were not the subject of very careful consideration by factory managers. Labor was plentiful and cheap, and as a result of the continuous excess supply, labor invariably, under the stimulus of retaining its hold on a job, was efficient.

All this has changed, and today the most important item in costs is labor. Very little attention had been paid, prior to 1914, to the use of labor-saving devices, and the plants were of such design that many of the standard forms of mechanical equipment, such as find use in the American industry, could not be utilized.

Factories erected during the war have had incorporated in their design a considerable amount of mechanical equipment, but in most cases these factories are not readily capable of change from specialized war products to staple chemicals, so that factory equipment as a whole is little in advance of pre-war conditions.

As a direct outcome of the discovery during the war of the power it possessed, labor has changed its former subservient relationship to capital, as represented by the factory owners, and at this present time it has apparent control of the industries. Hours have been shortened, rates of pay have been greatly increased, and the men no longer feel that there is any necessity of doing a real day's work. It takes more men to perform a given operation now than it did in pre-war times, and as rates are up at least 120 per cent, the resulting increase in cost of production can be imagined. One manufacturer told me that whereas his labor cost on a certain product was 11c. per 100 lb. before the war, it was now in excess of 30c., and likely to go even a shade higher.

There is a feeling of unrest in the factories which is not confined to the workmen, but extends to the salaried staffs, who have always before them the contrast of inefficient labor paid at high rates, and their own high living costs, high income tax rates, and only slightly increased salaries. As an instance of the general complaint in this direction, recent papers carried letters from a Judge and a Bishop, each presenting a budget of his expenses, and each proving rather conclusively that he could not make both ends meet without a substantial change in his pre-war salary.

Labor in the chemical industry was not organized before the war, as the only attempt to form a union (in 1895) failed through lack of support. Now there is a fairly strong union body, with about 40,000 members, affiliated with the National Federation of General Workers. A ballot is to be taken shortly by this union on the question of handing in notices to enforce 12 hours pay for 8-hour shifts with a 44-hour week, and there does not seem to be much doubt as to the result being in favor of the strike notices. So the path of the manufacturer seems to have difficulties present and ahead.

One totally unexpected feature is the disappearance of women from the industry. While the war was in progress, the English newspapers which reached America carried column after column about women who had found a niche in industry. Every trade opened its formerly closed gates to the woman worker, and by general consent women were conceded a permanent place in the industrial world. And now, before even demobilization is complete, women's hold on the industries has slipped, and without an apparent struggle the woman worker has been dispossessed and a man has her place. There are of course minor exceptions, but in the factories which were staffed by men in the pre-war days, women have done their day and service and are already passing into a remembrance. One friend, showing me through his plant, said: "I had over 200 women in this department from late '15 to early this year—but now I haven't one." He had no explanation as to why or where his women workers had gone, and he had too many other troubles to waste time on any abstruse speculations, the simple fact being that they had gone.

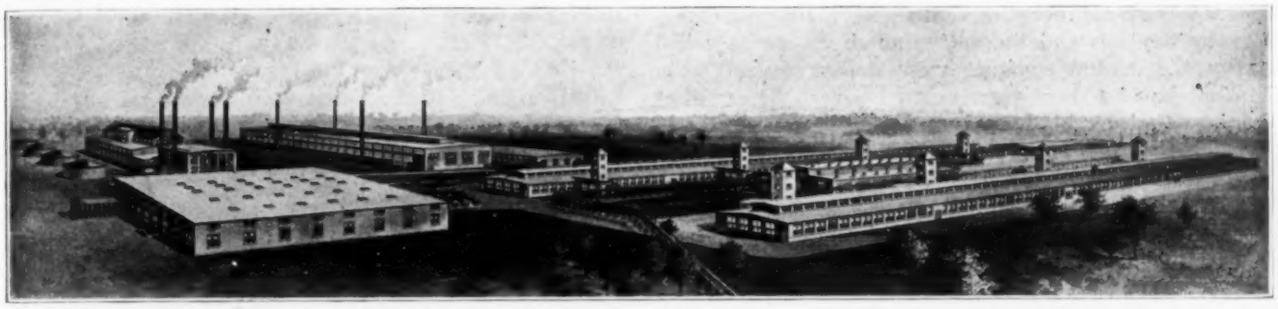
Another factory I have just visited was busy during the war in the manufacture of scientific apparatus. I had heard of this factory as an example of the development of women workers to a high state of efficiency, but I found only four women left, and men, incompetent because of inexperience, turning out work that was obviously crude.

So one of the questions which agitated England during the war, "What shall be done with women in the industries?" has quietly solved itself, and it is well within the bounds of past experience for the present labor difficulties to adjust themselves and disappear. A thoughtful labor man with a wide acquaintance among the labor leaders in various industries said in the course of conversation: "The workingman has every present intention of getting more pay for less work, and this is the direct result of the extravagant expenditures of the war profiteers, but the only solution I can see to the coming industrial crisis is increased work during the shorter hours our members have already secured."

Four years of war, four years of tense production, have brought in their train an inevitable slackness among the workers due to the removal of the stimulus, and just like a case of bodily overstrain, the recovery will have to be by gradual stages. Herein lies one of the dangers to the English chemical manufacturer. The change in the relationship between capital and labor has made his position indeed unenviable, as while the present high ocean freights protect his home market they prevent him from entering his high-labor-cost products into export competition.

Chemical manufacturers generally express their present fears of American competition in the export trade, and in the domestic trade as soon as transatlantic freights drop from their present high levels. There is a definite trend observable, even in the most casual talks with manufacturers, toward protective tariffs, and it seems certain that attempts will be made to preserve the domestic trade to English chemical manufacturers by the adoption of some form of protection.

London, England.



The United States Government Chlorine-Caustic Soda Plant at Edgewood Arsenal, Edgewood, Maryland

The Largest Chlorine Plant in the World—History of the Design, Building and Operation—Brine Purification Plant—Cell Installation, Concentration and Fusion Department—Chlorine Drier and Equipment—Caustic Soda

BY SAMUEL M. GREEN

SOON after the declaration of war against Germany, the War Department decided upon a very extensive poison-gas offense program. After much study of this comparatively new method of warfare, it was decided to build a Government plant for the purpose of manufacturing poison gases of all varieties and for filling the gas shells, bombs, hand grenades, etc.

Chlorine is the base from which practically every gas is made which is used in warfare. The War Department evidently expected to secure the required amount of chlorine gas from private plants, but as the gas program developed it became evident that the supply from such sources would be inadequate. The construction of the Government plant for the manufacture of poison gas, known as Edgewood Arsenal, was started in the fall of 1917. This arsenal is located about twenty miles north of Baltimore, Md., on Government property.

Manufacturers of electrolytic chlorine cells were requested late in December, 1917, to submit bids for the building of chlorine plants with capacities of from 15 to 200 tons. It was finally decided to build a plant having a capacity of 100 tons of chlorine gas per 24 hours, locating it at Edgewood Arsenal.

On March 3, 1918, the Procurement Division awarded a contract to the Warner Chemical Co. of New York, which owns the Nelson electrolytic chlorine-caustic soda patents[1], provided that it should furnish the United States Government 1776 Nelson 1000-ampere electrolytic chlorine-caustic soda cell units complete f.o.b. point of manufacture, having a guaranteed capacity of 50 tons of chlorine per 24 hours; that it furnish through the Samuel M. Green Co., engineers, of Springfield, Mass., complete plans and specifications for the buildings for the boilers, evaporators, Nelson cells, salt storage and preparation, caustic soda fusion, weak caustic storage, general stores and administration; complete specifications and plans for all auxiliary apparatus and piping, the buildings and auxiliary apparatus to be designed for a capacity of 100 tons of chlorine per day; that the company should arrange for supervision of construction of buildings and installation of apparatus by the officials of the Samuel M. Green Co. and for the general supervision of the starting and operation of the plant by H. R. Nelson, inventor of the Nelson cell, and Samuel M. Green, president of the Samuel M. Green Co., until such time as all guarantees had been fulfilled and the plant was being successfully operated by the Government officials.

The contract required that one-quarter of the total number of cells should be shipped on June, July, August and September 7, and that shipments should be anticipated as much as possible, the Government agreeing to provide for the installation of the cells as and when received.

In order that at least a small experienced force of men should have the necessary knowledge for installing and operating the plant, the Government agreed to furnish enlisted men who were to be sent at Government expense to the plant of the Warner-Klipstein Chemical Co., located at Charleston, W. Va., operator of a large Nelson cell plant, the Warner Chemical Co. agreeing that these men should be given every facility to acquire the special knowledge required for operating such a plant.

This arrangement solved the most difficult problem facing the engineers: i.e., an experienced operating organization. Its successful solution was largely due to the enthusiasm and splendid work of the officers and men who were sent to Charleston and to their untiring work at Edgewood during the installation and starting of the plant.

No definite action was taken by the Government in regard to the second 50-ton chlorine cell plant until about April 5, when Col. William H. Walker, commanding officer of Edgewood Arsenal, informed the engineers that it had been definitely decided to proceed with its installation. The award for the additional cells was placed with the Warner Chemical Co. on June 15, and this contract called for the delivery of one-quarter of the total number of 1776 cells on Nov. 1, 1918; Dec. 1, 1918; Jan. 1, 1919, and Feb. 1, 1919.

The entire number of cells called for by the first

[1] U. S. Patents 929,469; 1,149,210 and 1,149,211.

contract were delivered and erected ready for operation by Sept. 1, and the entire number of cells called for by the second contract were delivered and more than one-half of them were erected before the signing of the armistice.

Under the contract, it devolved upon H. R. Nelson and Samuel M. Green to devote practically their entire time to this project, for they were made entirely responsible for the design of the plant, supervision of its building and installation and its subsequent operation.

The Foundation Co. of New York was awarded the contract for building the chlorine plant in accordance with the plans and specifications and under the supervision of the engineers.

Lieut. Col. E. B. Ellicott, representing the Construction Division of the War Department, was placed in charge of the work, and to his great ability and untiring effort the success of the undertaking was largely due. The Construction Division in Washington drew off all quantities from the plans and purchased the materials.

Considering that it was almost impossible to secure labor in adequate quantity or quality; that it was constantly changing; the difficulties incident to divided authority between two organizations—one responsible for purchase and the other for the erection of materials; and other difficulties of those most strenuous times, the rapidity of the construction of this plant reflects great credit upon the Foundation Co.

The auxiliary apparatus for the plant was purchased under the direction of Col. Charles N. Black upon specifications furnished by the engineers. The purchase and control of the delivery of this apparatus was finally placed under the direction of the main office of Edgewood Arsenal, located at Baltimore, Md.

During the fall and winter of 1917 and 1918, work was in progress at Edgewood Arsenal on the buildings for the chemical plant for the manufacture of toxic gases, for the filling of gas shells, and housing for officers and men. On March 5, 1918, it was decided to locate the chlorine plant near the chemical plant then in process of construction, and plans of the general arrangement of the buildings were immediately made. On March 27, however, it was decided to place the chlorine plant about 1800 ft. from the chemical plant.

Electrical Installation

Sargent & Lundy, engineers, of Chicago, Ill., designed and supervised the installation of the electrical equipment for supplying direct current to the electrolytic cells.

The Government entered into a contract with the Pennsylvania Water & Power Co. to supply 20,000 kw. at 60,000 volts over a high tension transmission line ten miles long. A 20,000-kw. steam power plant was also built on Bush River to act as a reserve, but it was not completed before the signing of the armistice. Current was supplied to the cells from a rotary converter installation located between the cell buildings.

The generating apparatus consisted of the necessary transformers, switching arrangements and twenty-four 2000-amp. and two 4000-amp., 300-volt rotary converters of the booster type. Each 2000-amp. rotary converter supplied current to two cell circuits, each circuit containing 74 cell units. The 4000-amp. rotaries were

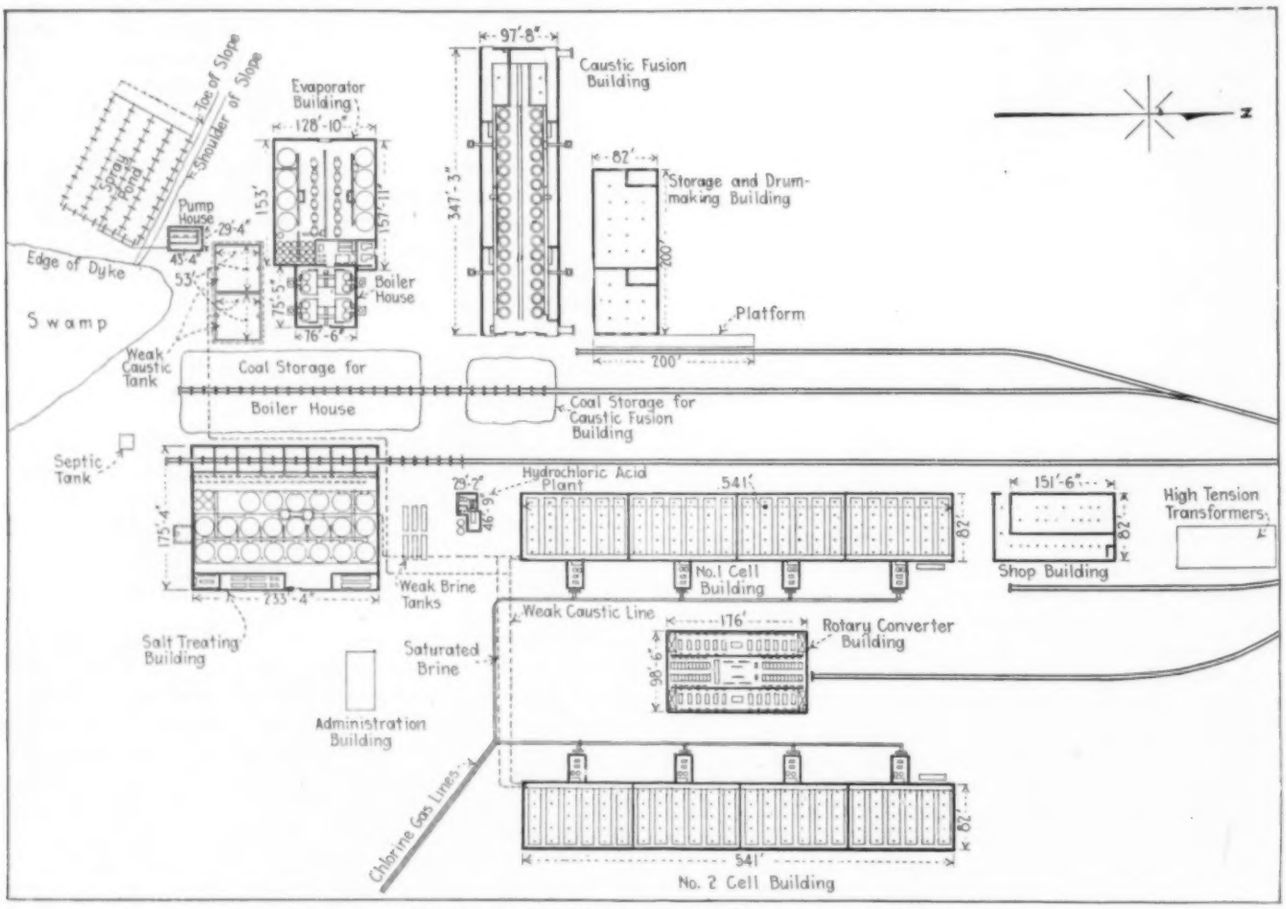


FIG. 1. GROUND PLAN OF THE CHLORINE-CAUSTIC SODA PLANT

FIG. 2. BRINE PURIFICATION TANKS

to be used as spare units and were purchased because they could be secured before the 2000-amp. units could be obtained. The maximum direct current required to operate the 3552 cell units would have been somewhat less than 14,000 kw. when the plant was producing 100 tons of chlorine gas per 24 hours.

The electrical current for the operation of the auxiliary apparatus and for lighting the plant was supplied from a power plant located near the filling and chemical plant. This power plant supplied current at 60 cycle and it was considered advisable to use this, as the current from the Public Service system was 25 cycle and it was found impossible to secure standard motors at this frequency within a reasonable time.

General Arrangement

The chlorine plant buildings, a ground plan of which is shown in Fig. 1, consisted of a salt storage and treating building, two cell buildings, a rotary converter building, a building for machine shop and general stores, a high tension transformer yard, a boiler, power and evaporator building, weak caustic liquor storage tanks, a water pumping building and spray cooling pond, a caustic fusion building, and a drum making, caustic cooling and shipping building.

In connection with the chlorine plant, there was also constructed a liquefying plant for chlorine, a sulphur chloride making and sulphur distilling plant. This equipment was located about 1800 ft. from the chlorine plant and near the chemical plant.

Salt Storage and Treating Building

The salt storage and treating building, Fig. 2, was located on ground much below the cell building's elevation and allowing the railroad to enter the building on the top of the salt storage tanks. These tanks were constructed of concrete. There were seven of these tanks, each 34 ft. long, 28 ft. wide and 20 ft. deep, having a capacity for storing 4000 tons of salt. There would have been 200 tons of salt used per day when the plant was running at full capacity. The salt was shoveled directly from the cars into these bins, an automatic grain shovel being provided for this purpose.

On the bottom of each tank distributing pipes for dissolving water supply were installed, and at the top of each, at the end next to the building, there was an overflow trough and skimmer board arranged so that the dissolving water, after flowing up through the salt, overflowed into this trough and then into a piping system and into either of two collecting tanks.

The piping system for delivering dissolving water to the storage tanks and for collecting the brine from the tanks was arranged so that dissolving water could be delivered to any tank, returned to one of the collecting tanks, and then be delivered to another storage tank and back to the second collecting tank. This arrangement was made so that all of the salt in any storage tank could be dissolved, and if the brine was not fully saturated it could be passed through another storage tank containing a deep body of salt and thereby be fully saturated. The saturated brine was pumped from the collecting tanks to any one of 24 treating tanks. Each of these tanks had a capacity of 72,000 gallons.

The eighth concrete storage bin was used for the storage of soda ash used in treating the saturated brine. Soda ash was delivered from the cars into this bin and was delivered from the bin on the floor level of the salt building to the soda ash dissolving tanks. From these tanks, the solution was pumped in desired quantity to any one of the 24 treating tanks. After the

FIG. 3. CHLORINE CELL BUILDING DRYING TOWERS AND PIPE LINE

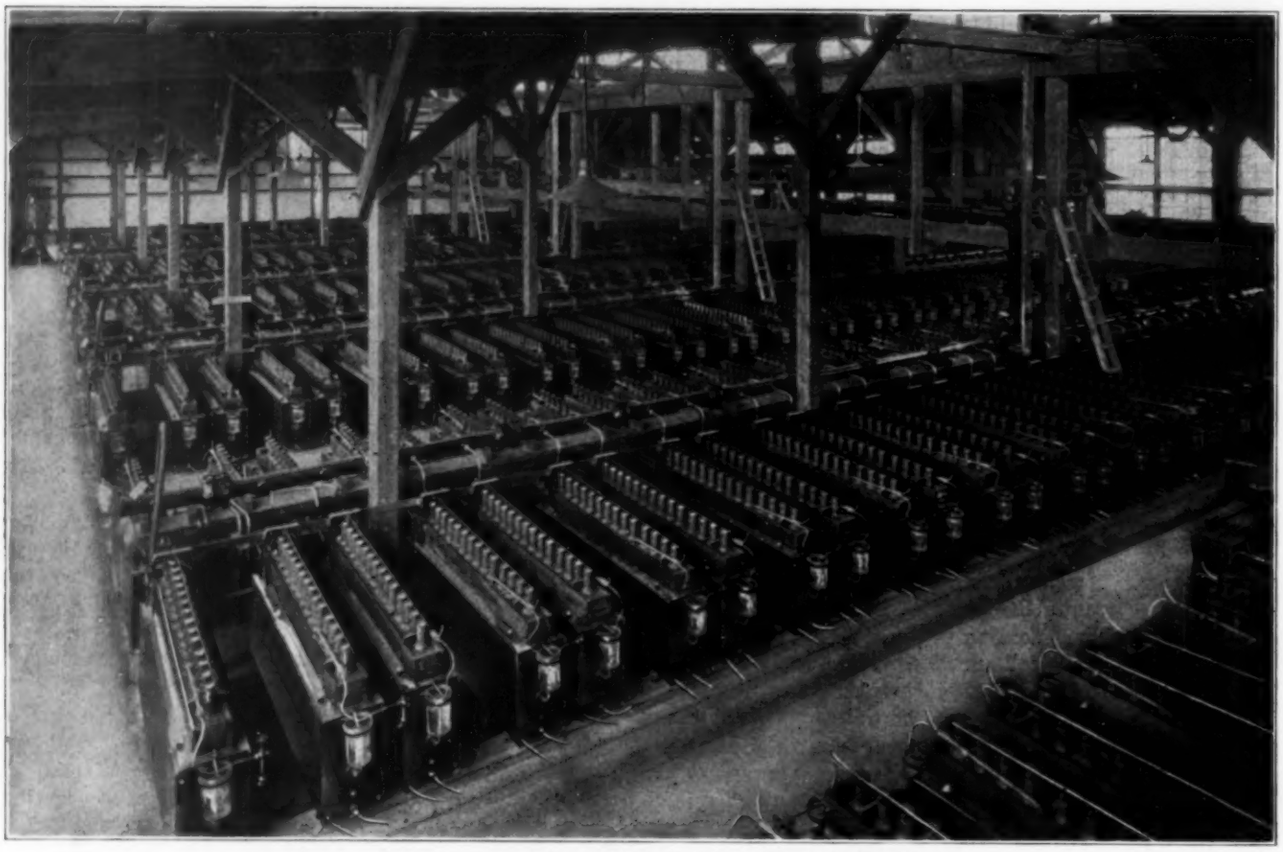


FIG. 4. CELL ROOM, SIX BANKS OF 74 CELLS EACH

brine was treated and settled, the clear, saturated brine was drawn from the treating tanks through decanting pipes and delivered by pumps to any one of four neutralizing tanks.

These tanks were located next to a platform on the level of the car body, above the top of the salt storage bins, and hydrochloric acid was delivered directly from the cars to this platform, providing a large storage capacity for this acid. The platform level was about 30 in. below the level of the top of the neutralizing tanks and the acid was easily dumped into the tanks from the carboys. It was at first expected that the acid would be purchased, but it was finally decided to make it by the use of chlorine and hydrogen from the cells, and a plant for this purpose was designed and erected.

The neutralized brine was delivered from the tanks by a pump to a tank located at a height above the floor so that the brine would flow by gravity to the cells in the cell buildings. This tank was kept at a constant level by use of float valves and gave a constant hydraulic head to the cell feeding devices. The floor of the salt building was of concrete provided with open drains leading into a large concrete sump. Any leakage of brine was thus collected and returned to the system. The entire tank equipment was of wood and was purchased from and erected by the John Eppler Co., Baltimore, Md. The work was carried out in a most excellent manner, as is evidenced by the fact that there was practically no leakage. There was a chemical laboratory in one corner of the building for the chemical control of the brine. Two acid tanks were installed in this building, into which the weak sulphuric acid from the chlorine gas drying equipment in the cell buildings flowed by gravity. As these tanks filled, they were emptied into tank cars on the track above the salt storage tanks, and these cars delivered the acid to an acid drying plant located near the chemical plant. The acid after being dried was returned to the cell buildings for re-use.

Electrolytic Cell Buildings

There are two cell buildings, each 541 ft. long by 82 ft. wide and separated by partitions into four sections containing six cell circuits of 74 cell units. Each section is a complete unit in itself, provided with separate gas pump, drying and cooling equipment, and has a guaranteed capacity of 12.5 tons of chlorine gas per 24 hours.

The gas piping from the individual cell units to and including the drying equipment is of chemical stoneware. The piping was designed so that the gas could be drawn from the cells through the drying equipment at as near atmospheric pressure as possible in order that the gas could be kept as free of air as possible. When operating, the suction at the pump was kept at $\frac{1}{10}$ in. or less of water. The quality of the gas was guaranteed under the contract to contain at least 95 per cent Cl, and during the operation it was maintained at 98.5 to 99 per cent. The gas cooler design is shown in Fig. 5. These coolers were very effective, the gas being cooled to within 1 deg. of the temperature of the cooling water.

The drying apparatus consisted of a stoneware tower of special design containing a large number of plates, giving a very large acid exposure. There was practically no loss of vacuum through the drying tower and cooler. The stoneware equipment furnished by the General Ceramics Co. of New York was of the most satisfactory character. The gas pumping equipment for

each section consisted of two hydro turbine pumps using sulphuric acid as the compressing medium. They were direct connected to variable speed motors. (See Fig. 6.) The acid was cooled by circulation through a double pipe cooler similar to those used in refrigerating work. The pumps were made by the Nash Engineering Co. of South Norwalk, Conn. The gas was delivered under about 5 lb. pressure into large receiving tanks located just outside the pump rooms, and from these tanks into steel pipe mains which conducted the gas to the chemical plant, a distance of about 1800 ft. Three mains were provided and connected so that one was held in reserve to be used if repairs became necessary.

Nelson Elctrolytic Cell

Each Nelson electrolytic cell* unit consists of a complete fabricated steel tank; a perforated steel diaphragm spot welded to supporting angle irons; sectionalized machined plate gas dome; fourteen pieces 2½ in. diameter, 12 in. long, and fourteen pieces of 4 x 4 x 17 in. Acheson graphite electrodes; anode supporting pins; sufficient asbestos cloth and paper for the diaphragms; copper bus bars; copper connectors from cell to cell; copper ears to connect the angle iron supports of the perforated steel diaphragm; glass insulator supports for the steel tanks; glass cells for caustic, condensation and chlorine gas discharge; hard and soft rubber tubing and rubber stoppers, bolts, nuts and washers; and automatic feed.

*A detailed description of the Nelson electrolytic chlorine cell will be published as a separate article in a subsequent issue.—Editor.

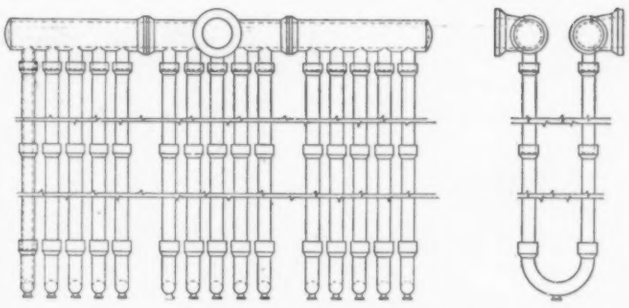


FIG. 5. GREEN STONEWARE CHLORINE COOLER

Each Nelson cell unit is guaranteed to produce 60 lb. of chlorine gas and 65 lb. of caustic soda, using not in excess of 120 lb. of NaCl (salt) per 24 hr., the gas to be at least 95 per cent pure. These guarantees were largely exceeded.

The salt solution from the cell feed tank, located in the salt treating building, flows by gravity through a piping system located in a trench running the length of each cell building, and is delivered to each cell unit through an automatic feeding device which maintains a constant liquor level in the cathode compartment.

The solution percolates from the cathode compartment through the asbestos diaphragm into the anode compartment and flows from the end of the cell, con-

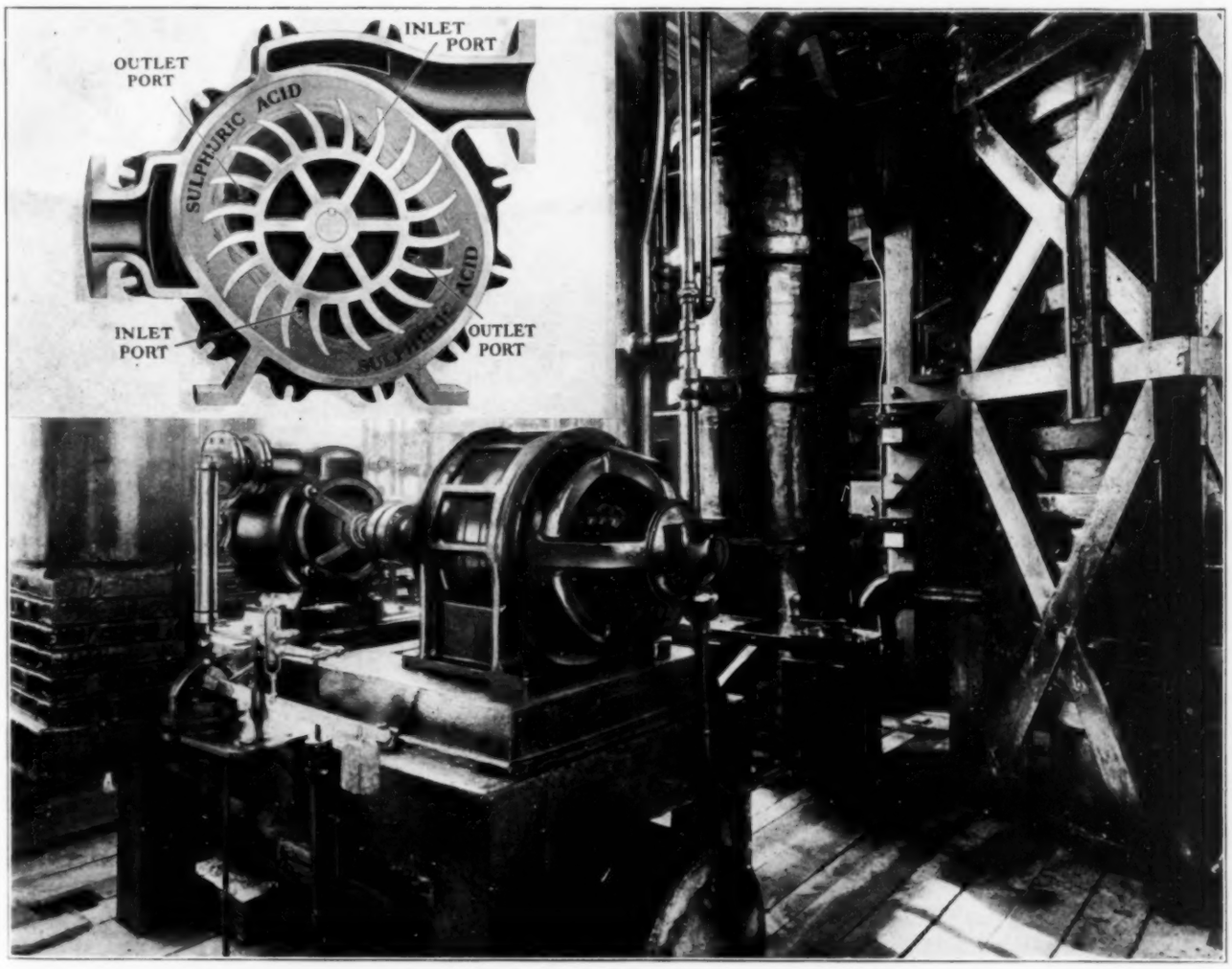


FIG. 6. HYDROTURBINE OPERATING AT EDGEWOOD ARSENAL (INSERT, CROSS-SECTION)

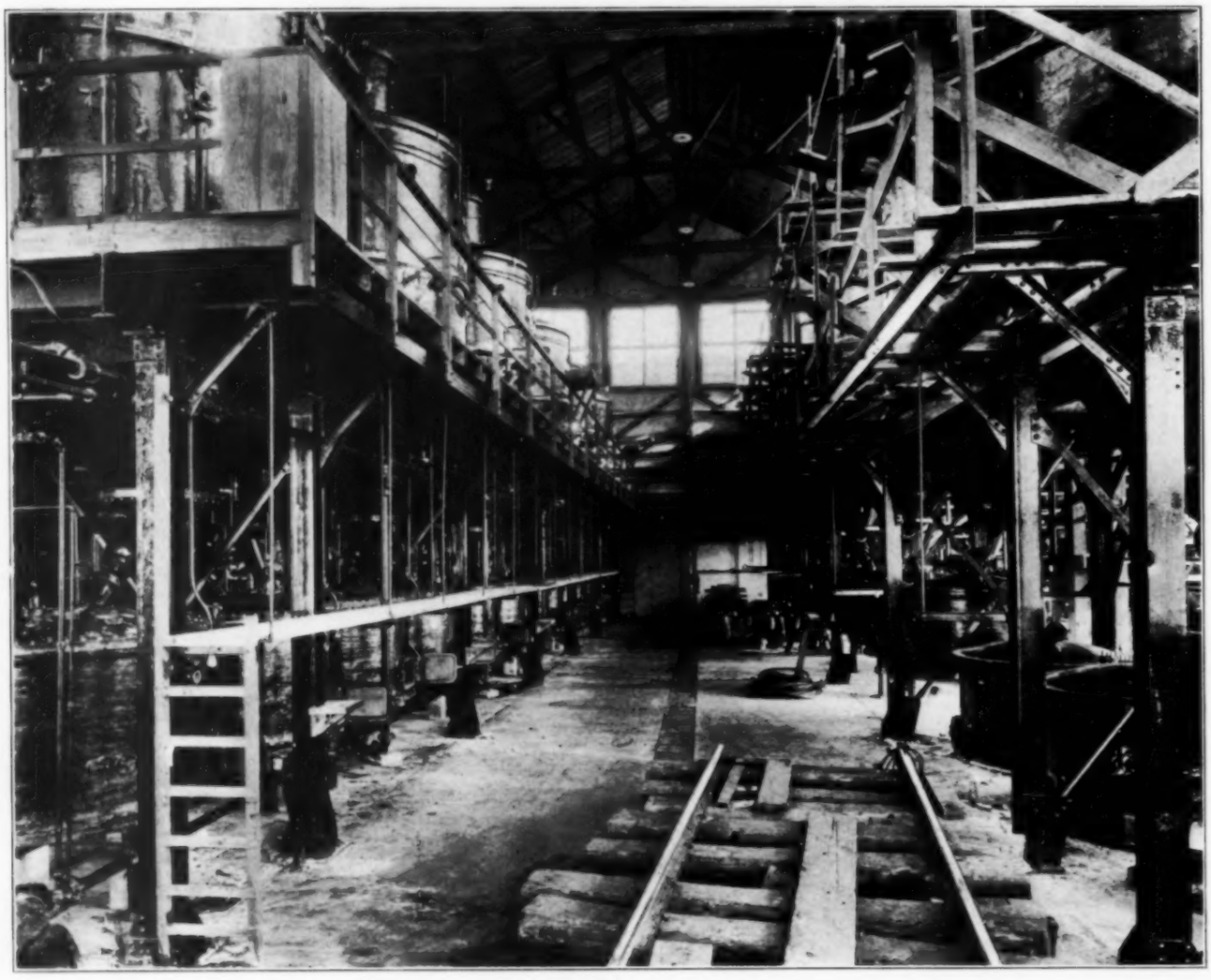


FIG. 7. EVAPORATOR BUILDING

taining from 8 per cent to 12 per cent caustic soda admixed with 16 per cent to 14 per cent salt, into an open trough and into a pipe in the trench, and through this pipe it flows by gravity to the weak caustic storage tanks located near the caustic evaporator building. These tanks were made of concrete for it was practically impossible to secure steel for tanks.

Boiler and Evaporator Building

The boiler and evaporator building is on the same level as the salt treating building. Owing to natural grade of the ground, a railroad trestle was built between the salt treating building and the boiler house, and coal was dumped by gravity into this natural coal pocket.

The boiler house contained eight 500-hp. Wickes vertical water tube boilers built by the Wickes Boiler Co., Saginaw, Mich., each equipped with a mechanical stoker built by the Detroit Stoker Co. of Detroit, Mich. The boiler house was designed for a complete automatic coal and ash handling equipment, but owing to the probable temporary operation of this plant it was not considered advisable to make the investment required for this equipment. The coal was handled by a crane with a grab bucket, delivering it into a small hopper situated at such a height that coal cars operated by hand could be run under the hopper, the cars being on a level with the top of the automatic stokers. The ash was delivered into a car and pushed to an ash pile by manual labor.

In a room next to the boiler room (see Fig. 8), there was located a feed water heater, two large horizontal air compressors for furnishing air for agitating the brine and for handling acids, etc., two refrigerating machines for producing cold water to cool the chlorine gas, and two 750-kw. alternating-current steam turbo generating units.

The chemical and filling plants required a large amount of power, and it was therefore thought advisable to install steam turbines at the chlorine plant to operate in synchronism with the turbines at the chemical plant. The turbines at the chlorine plant operated with 160 lb. steam pressure and exhausted against 20 lb. back pressure, the exhaust steam being used by the caustic evaporators.

The total steam required by the evaporators would have produced about 1500 kw. per hour, and as the turbines were operated in synchronism with the large power units located at the chemical plant, the quantity of steam delivered by the turbines could be regulated to the exact amount required by the evaporators, and the power produced was at an exceedingly small fuel cost. This arrangement would have proved of great advantage, for it was found that the power provided at the chemical plant was not sufficient for the requirements

and the power produced by the back pressure turbines was at very small expenditure.

Caustic Evaporator

The caustic evaporators were furnished by the Zaremba Co. of Buffalo, N. Y. The equipment consisted of six 108-in. double effect evaporators arranged on each side of the center of the building and under a traveling crane. Each set of six bodies was arranged to operate as three double effects and was connected to one large barometric condenser.

The water supplied for these condensers was from a cooling pond made by a natural depression in the ground outside of the evaporator building. The soil was of red clay, practically impervious to moisture, and therefore nothing had to be done to make a pond except clearing the ground of vegetation. The water from the condensers flowed by gravity to a centrifugal pump which delivered it to the spray heads, flowing from the pond back to another pump which delivered it back to the condenser. Caustic coolers were provided for cooling the caustic as it came from the evaporators.

Back of each line of evaporators there were four steel tanks of a capacity of 79,000 gal. each, for receiving the concentrated caustic liquor and storing it before it passed to the fusion building. The pumping equipment in the fusion building for handling weak and concentrated caustic liquor consisted of centrifugal pumps directly connected to motors. They were installed practically in duplicate so as to insure continuous operation.

Caustic Fusion and Drum Making Buildings

The caustic fusion building is located near the evaporator building and is arranged for 36 caustic fusion pots set in two rows. Thirty pots were installed.

The pot floor is about 7 ft. above the firing floor and on a level with the drum making building. Over each row of pots there are two cranes with a capacity of fifteen tons and one ton respectively. These cranes are on separate tracks, the small one being located below the large one. The large crane was for handling the pots, and the small one for handling the centrifugal pumps which were provided for emptying the fused caustic from the pots into the drums.

The drum-making building is located near the fusion building, and a railroad track comes to it with the car-floor level with the building-floor. The end of this building next to the track was provided with a brick floor and used for cooling filled caustic drums. The rest of this building was used for drum making machinery, storage of steel and drum manufacture.

Motor-operated elevating trucks were provided for handling empty and filled drums. Steel skids were provided carrying six drums each. The truck picked up these skids and transported them to the caustic pots. They were filled with caustic by the pump provided for this purpose; then they were transported to the drum making building, where they were allowed to cool while still on the steel skid. When cool, they were delivered to cars and shipped.

Sulphur Chloride Plant

A method was devised for the manufacture of mustard gas by the use of sulphur chloride. It therefore became necessary to manufacture a large amount of this chemical. The engineers were instructed to design a plant for the manufacture of sulphur chloride and the method devised by Mr. H. R. Nelson was used. The design of this plant was started about June 15 and the plant was put in successful operation September 1, 1919.

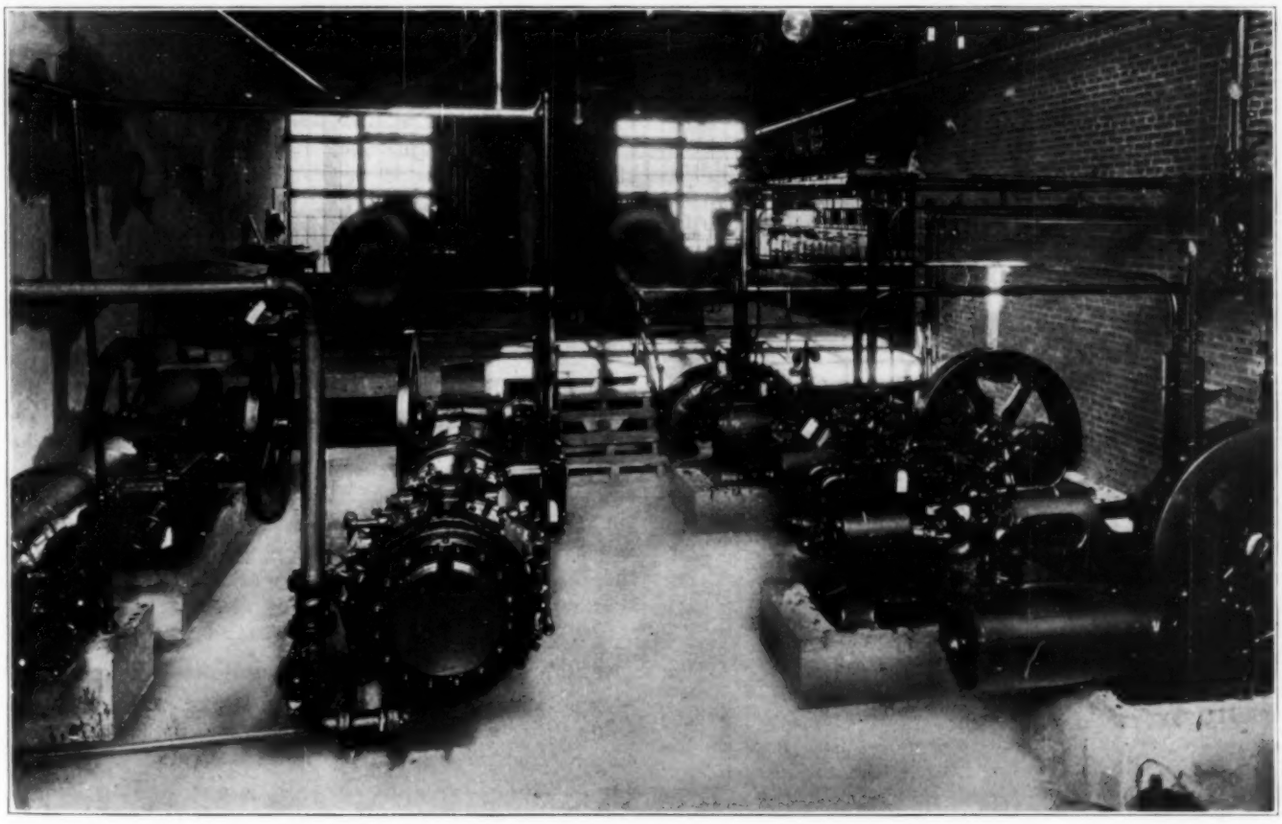


FIG. 8. PUMP HOUSE, AIR COMPRESSORS AND TURBINES

FIG. 9. CAUSTIC FUSION AND DRUM CHARGING BUILDING

LIQUID CHLORINE PLANT

It was decided that it would be best to build a plant for the liquefaction of chlorine gas to insure a pure supply of chlorine for manufacture of phosgene gas and to supply liquid chlorine for certain types of gas shell.

Owing to the fact that the Nelson cell produced such a very high quality of gas, it was found that it was not necessary to liquefy the chlorine for use in manufacture of phosgene. The liquefying plant was constructed from details furnished the Government by the Mathieson Alkali Co. of Niagara Falls, and the plant was erected under the direct supervision of Lieut. Col. Charles F. Vaughn, who came from the Mathieson Alkali Co. and was placed in charge of the chlorine gas plant. This plant was placed in operation just before the signing of the armistice.

The contract for the design of the chlorine plant was awarded on March 3, 1918. Definite location of the plant was decided March 27. The railroad track for serving the plant was completed May 8. Ground was broken for the shop building May 10. The first circuit of cells was ready to operate Aug. 1.

The first section of No. 1 cell building, having a capacity of 12.5 tons of chlorine gas per 24 hours, was started in operation Sept. 1, the circuits in this section being put in operation as rapidly as the chemical plant could absorb the gas. There were no difficulties encountered in starting, and operation was continued until the signing of the armistice. The plans furnished by the engineers were carried out without any changes during or after construction, and their estimates of cost would not have been exceeded had it not been for the extraordinary cost of labor due to high wages, much overtime and inefficiency.

The success of the entire work at Edgewood Arsenal was largely due to the great executive ability and personal force of Col. William H. Walker, upon whose shoulders rested the entire responsibility. All of his associates will remember him with admiration and respect.

Samuel M. Green Co.
Springfield, Mass.

American Institute of Mining and Metallurgical Engineers, Chicago Meeting

PLANS for the meeting of the American Institute of Mining and Metallurgical Engineers at Chicago next September are assuming definite form, and the committee in charge announces the following schedule of events:

On Monday, Sept. 22, the opening day, the morning will be devoted to registration of members and guests at the convention headquarters, the Congress Hotel. Monday afternoon the first session for presentation and discussion of technical papers will be held, and in the evening a smoker, at which the committee guarantees all traces of glaciation will be dissipated.

It is planned to make an excursion on Tuesday in a body, by a boat chartered for the occasion, across the south end of the lake to Gary, for a trip through the famous steel mills. Wednesday will be devoted to technical sessions, morning and afternoon, and in the evening the banquet will be held at the Congress Hotel, at which all members of the Institute and their wives will be the guests of Chicago.

On Thursday, a special train will convey the members and guests to La Salle and Depue, Ill., where the zinc smelters, coal mines and cement works will be visited. For those to whom these industrial operations are not of particular interest—this may include many of the ladies—there will be a trip by automobile to Starved Rock and other points of historical interest in the vicinity of La Salle.

For Friday, several optional excursions have been planned to local industrial plants. One trip will take in the lead refineries at East Chicago and the Standard Oil Refinery at Whiting. Another excursion will be to Milwaukee, to the plants of the Allis-Chalmers Co. and the Power Mining Machinery Co.; this trip will also include the metallurgical works at North Chicago of the Fansteel Products Co., where novel electrothermal processes in the production of metallic tungsten, molybdenum, cerium, and tantalum will be demonstrated.

For those interested in coal mining it is planned to have an excursion to the fields in Franklin and McCoupin Counties, leaving Chicago late Friday evening and spending Saturday at the mines.

Importation of German Scientific Books

In order to obtain a license for the importation of scientific books or journals which were printed in Germany, it will be necessary to deposit the purchase price with the American Relief Administration, so that the money may be available for the purchase of foodstuffs for Germany. The duplicate receipt issued by the American Relief Administration must be submitted to the Bureau of Imports of the War Trade Board when the application for the license is filed.

Removal of Tin Import Restrictions—Correction

The dates for shipment from point of origin and for entry have been changed by a recent War Trade Board ruling from those given in CHEMICAL AND METALLURGICAL ENGINEERING, June 15, 1919, p. 638, to June 30 and Aug. 1, 1919, respectively. Licenses for the purchase of tin are no longer required.

New and Rapid Apparatus for Electrochemical Analyses

By J. T. King*

IT HAS long been recognized in electrochemical analysis that agitation of the electrolyte hastens deposition of the metals. In an effort to keep apace with the modern demand of more speed in analysis, many mechanical devices and artifices have been introduced, employing the agitation principle. The best known types of these employ rotating anode, rotating cathode, rotating paddle, solenoid, and air streams. Analyses which formerly required many hours can now be satisfactorily performed in a few minutes. This saving in time has so revolutionized the usefulness of many electrolytic methods that the old objection of the time required can no longer in fairness be held against them.

While observing some of the apparatus employing moving electrolytes in operation, it occurred to the writer that stirring an electrolyte by rotating its containing beaker would be a more suitable and efficient method of agitation than others then in use. A careful search of the literature showed that no apparatus employing this principle had been described. The only

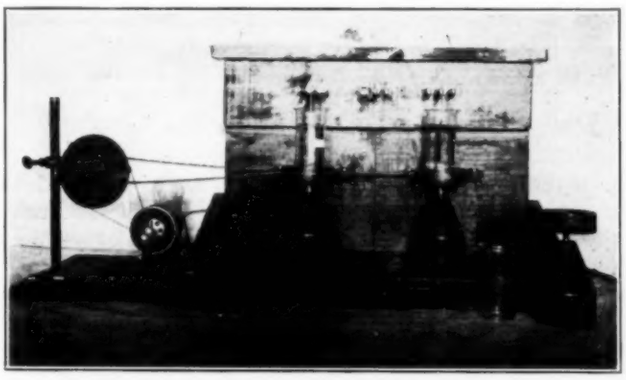


FIG. 1. THE EXPERIMENTAL DESIGN

reference to it having been tried was found in Smith's "Electro-Analysis." In mentioning the work performed by Klobukow (1886), one of the earliest investigators in rapid electro analysis, Smith states: "In his efforts to contrive mechanical devices, he rotated the cathode, and then the anode; indeed, he even held the electrodes stationary while moving the electrolyte." Before experiments were begun to ascertain the suitability of the new method of securing agitation, it was felt that, provided it was efficient, little would be gained unless simple and convenient apparatus could be designed to apply it in everyday use.

In the assaying laboratories of the Departmen of Mining Engineering at the University of Toronto, the "Guess Haultain electrolytic outfit" (*Trans.*, A. I. M. E. Vol. 36) is used. It seemed that the rotating beaker idea could be successfully applied to this design, thereby retaining its best features, with the added advantage of speed.

Experimental Design

The apparatus was modified as in Fig. 1. Here three electrodes per cell were used, the cells being in series. A belt moving over the idlers provided means of revolving the upper parts of the stands, on which the beakers stood in a cup ¼ in. in depth. The lower part of the stands was weighted with lead, to impart stability when the upper part was in contact with the belt. Not over 60 r.p.m. could be used, as the beakers wabbled badly because of the small lateral support given by the cups. To overcome this the cups were increased in depth, when it was found that interference with the electrodes rendered difficult the operation of placing the beakers in position, also their removal. The cells were short circuited by inserting a metal plug between the electrode holders. Considerable speed and dexterity were essential in removing a cell with its stand, and introducing the plug, so that the current would not be broken while any of the cathodes with their plating were in contact with the acid solutions. Without rotation it required 10 hours to plate 1 g. of copper using N.D.$_{100}$ 3 amperes. The modified form reduced this time to two and a half hours.

An Improved Design

Profiting by the defects and limitations of this apparatus, another was made, shown in Fig. 2. The beakers were supported in cups, but these were fixed centrally under the electrodes above, and rotated by a belt from beneath. The cups were drilled a little large and in an annular recess inside, rubber tubing was placed to grip the beakers and take care of variations in their diameters. The electrode holders were movable vertically, electric contact being made in the upper compartment. These were of clamp form, and were a marked improvement over the rigid split holders, as they accommodated themselves to the variations in the thickness of the electrodes. Besides the three electrodes formerly used, a fourth or auxiliary one was introduced, placed behind the cathode and in parallel with it. At the end of an electrolysis, before the cathode was raised from its electrolyte, the auxiliary electrode was lowered into the solution. In this way none of the cells in the series were short circuited by the removal of the cathode, and current passed to it as long as it was in the electrolyte.

Good deposits of copper were obtained with as high as N.D.$_{100}$ 8 amperes, and 1 g. plated in 1½ hours. Rotating speeds up to about 200 per min. were practical; above this the flat cathode acted too much as a baffle, and splattered the solution out of the beaker. With

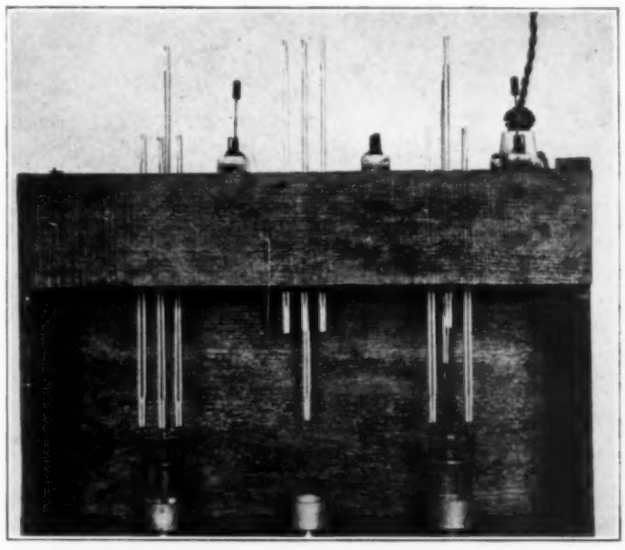


FIG. 2. THE APPARATUS IMPROVED

*Lecturer in mining engineering, University of Toronto.

the higher current density and higher rotating speed used here, it was expected that plating would be more rapid. It was noted that the plating was much heavier at the sides of the cathode than at the center; its whole area was not efficiently used. This was probably because the agitation in the beaker was more complete away from the central zone of the solution. The experiments showed that the flat form of electrode was not adapted to the method of agitation used. Cylindrical gauze cathodes were tried and found to be particularly adapted to the rotating beaker idea. Their use eliminated the necessity of a third electrode, as one anode placed in the center was sufficient. High rotating speeds could be used without the ill effects previously mentioned and uniform plating over the whole surface obtained. The apparatus would do excellent work in the hands of a sympathetic operator, but was not sufficiently practical for general use.

Description of Final Design

The final form of apparatus developed is shown in Fig. 3. Here many features have been incorporated to simplify the operation of rapid plating devices. The chief features which distinguish this from others, besides the novel method of stirring the electrolyte, are the system of wiring and the form of electrode holders. Fig. 3 shows four cell units marked *A*, *B*, *C* and *D*. *A* and *B* are in operation, *C* is being lowered from its electrodes, *D* is at rest. In the left hand compartment are housed a motor, its rheostat, a pilot lamp, ammeter, switch and two loose pulleys. A belt from the motor passes over the pulleys to the open or cell compartment, along the front and rear of four idler pulleys 1, Fig. 6, and around an end pulley. These are of aluminium with steel shafts running on a ball in the bronze bearings, supported on a cross frame. The five pulleys are

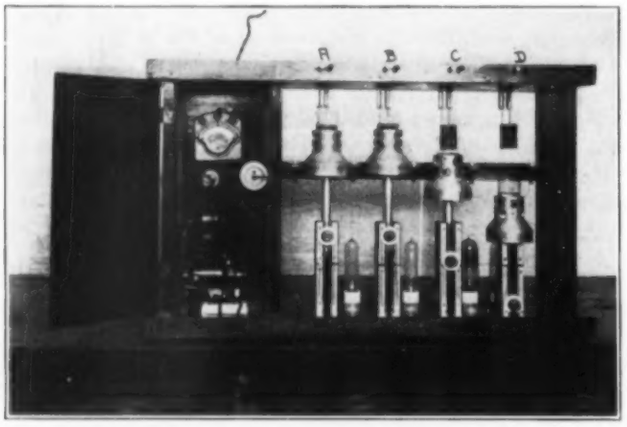


FIG. 3. FINAL FORM OF APPARATUS

spaced equidistant from the units in front. Four perpendicular wooden guide posts 2, see Fig. 6, attached to the base of the cabinet, are bored longitudinally and open to the front in a narrow slot 3. On each side of this slot are fastened upper and lower aluminium face plates 4 and 5. In the hole of the guide posts are long hollow cylindrical bearing tubes 6, of aluminium. From the lower part of these a threaded rod 7 extends forward through slot 3. On each rod in order from the face plate are an aluminium washer 8, known as the sliding contact, a rubber washer 9, and a nut 10. The bearing tubes are movable up and down the guide posts, and are held in any desired position by the tension of the rubber as adjusted by the nut. Steel spindles turning on a ball in the lower of two bearings of the tubes support the beaker cups 11, above. The cups have two rows of inwardly projecting rubber plugs, arranged to frictionally engage the beakers, thus centering them and accommodating any variations in their diameters that may occur. Above the cups are the electrode holders, one, 12, over the spindle axis or center of the beaker and one, 13, offset to the left. These are of broad clamp form, the outside jaw of each being stationary, the other movable. After passing up into the hollow

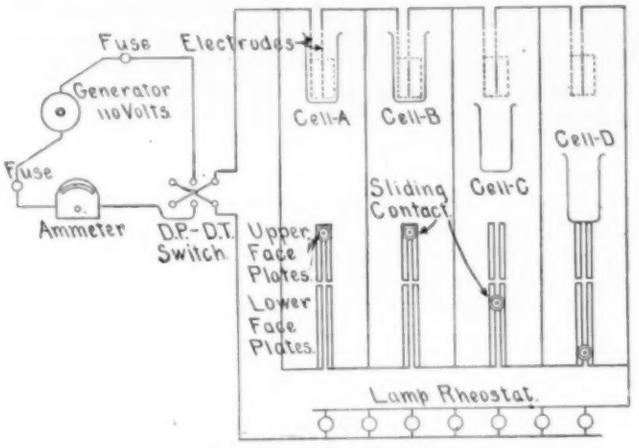


FIG. 4. DIAGRAM OF ELECTROLYSIS CIRCUIT

top of the cabinet, these turn at right angles in wooden guides. A coil spring holds the jaws together. Push buttons 14 and 15 operate the movable jaws when desired. The electrical wiring is enclosed in hollow compartments with removable lids at the base top and back of the cabinet. Fig. 4 shows the electrolysis circuit diagrammatically, beakers being shown to correspond to the beaker positions in Fig. 3. The connection to the 110-volt. d.-c. lighting circuit used, and the lamp rheostat to control the cell current, are shown in Fig. 5, a rear view of the apparatus.

Operation

To follow the operation of the apparatus assume that the cups are in the lower position, as is cup *D* of Fig. 3. Beakers ready for electrolysis are in the cups, electrodes are in position, the belt is in motion at the desired speed as controlled by the motor rheostat. The current adjusted by the lamp rheostat will pass across the lower face plates through the sliding contacts. To operate any cell, it is raised by lifting the sliding contact nut until the electrodes are immersed in the electrolyte. On the way up, the cone face of the cup engages the belt and rotation begins. At the moment the sliding contact passes from the lower to the upper face plates, which are insulated, the electrodes will have met the electrolyte, current then passes through the cell. Any other cell may be put in operation similarly.

To terminate electrolysis on any cell, it is lowered to the starting position. The operator, with a beaker of wash water in one hand, lowers the sliding contact with the other hand, as shown in Fig. 6, transferring the water to the plated electrode quickly. The electrode is disengaged by pressing its button. While the cell is being lowered the current continues to pass through the electrolyte until the moment the solution leaves the elec-

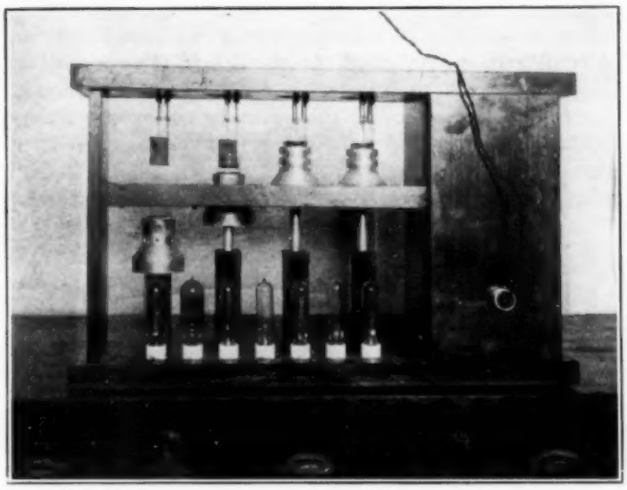


FIG. 5. CONNECTION TO LIGHTING CIRCUIT, AND LAMP RHEOSTAT

trodes, when the sliding contact has engaged the lower face plates. Then the current passes through the lower circuit of the cell. Thus the current is not broken in other cells that may be in operation, they are protected from resolution, and current is on the electrode being removed as long as it is in contact with its electrolyte. The procedure is extremely simple, convenient, speedy and positive.

The usual manner of fastening electrodes to their holders is by screws, chucks, slots and similar devices. Some of these are ruinous to the platinum ware that is used, and are difficult to clean when attacked by vapors from the electrolyte. They often do not give sufficient area of contact, causing burning of the electrode and consequent loss in weight. The contact area of the holders here is broad and smooth. The tension on the springs is adjusted so that while firm hold is exerted on the electrodes, it is not sufficient to injure them in any way. The faces are easily accessible for any cleaning that may be necessary, so that a perfect contact is assured. The push buttons provide an easy and quick way of inserting the electrodes and removing them. The set of four cathodes may be easily removed, rinsed in two changes of water, then two of alcohol, and set to dry, hanging over the lamps of the rheostat, in eighty seconds.

The apparatus runs very smoothly, requiring a minimum of attention from the operator. The ammeter and motor, being housed in a separate compartment, are amply protected from fumes and dust, and aluminium has been utilized wherever practicable in the exposed metal parts. The $\frac{1}{2}$-hp. motor used would operate many more units, so little power is required for rotation. It is balanced on a hinge underneath, thus accommodating itself to any changes occurring in the belt position when units are started or stopped.

Tests for Speed and Accuracy

In order to ascertain the speed of plating and the accuracy of the work, a number of analyses were made on copper solutions of known strength, and on unknown brasses. In order to determine the copper content of the copper wire used to make up the known solutions, duplicate analyses by electrolysis were made with gauze electrodes and still electrolyte. The method followed was that given by Heath in his "Copper Analyses," for "The Standard Five-Gram Electrolytic Assay." These gave 4.9906 and 4.9903 g., or 99.81 per cent copper.

The known solutions were made as follows: About 20 g. of the wire were carefully weighed, heated on a water bath with 40 cc. nitric acid, 40 cc. sulphuric acid and 100 cc. of water, until all the wire was in solution and nitrous fumes were driven off. When cool, the cover glasses and sides were washed down and the solution diluted to one liter at 15 deg. C. For the tests aliquot parts of 50 cc. were pipetted at once, using a pipette agreeing with the flask and transferred to the electrolysis beakers. Fifteen cc. of a saturated solution of potassium nitrate and 25 cc. of water were added, making 90 cc. of solution. This volume filled the beakers (new form, tall Fry) over half full, leaving over 1 in. clear at the top.

On several occasions while working with other apparatus it was observed that when higher current densities and an electrolyte containing nitric acid were used, the copper deposit actually dissolved off the cathode, while current was flowing, faster than the current flowing could plate it. In order to overcome this and retain the same character of deposit obtained at lower current densities, an equivalent amount of potassium nitrate was substituted for most of the nitric acid. When this was done the deposits were satiny, pink and adherent.

Cylindrical cathodes, 2 in. high and $1\frac{3}{4}$ in. diameter, of 28-mesh, 28-gage copper gauze, were used. The stems were No. 16 copper wire, pushed through the top and bottom of the narrow lap of the gauze, the bottom end was turned back over the gauze and pressed to it. The upper ends of the stems were formed into an open loop, about $\frac{1}{2}$ in. in diameter. These afforded large

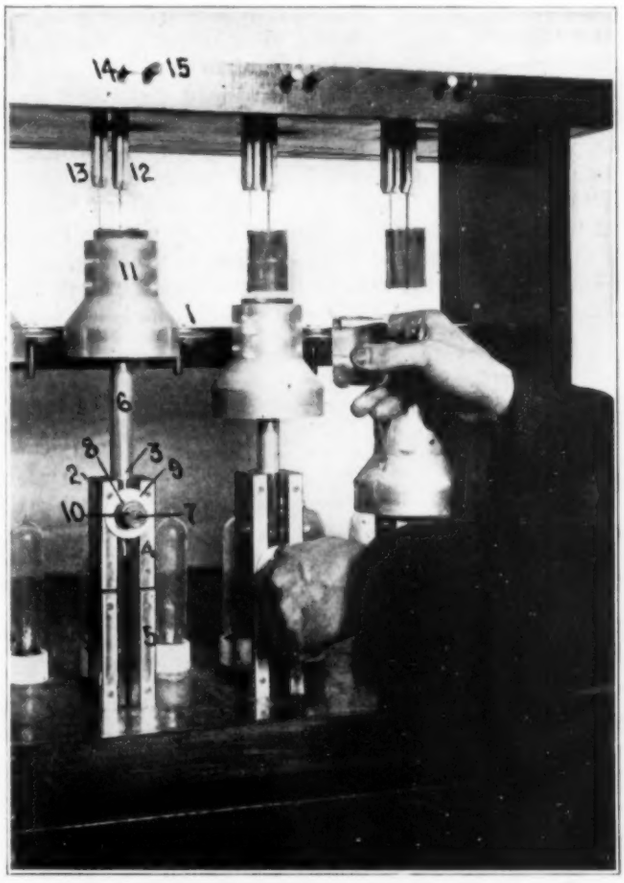


FIG. 6. OPERATOR TERMINATING ELECTROLYSIS

area of contact with the holders, and were easily hung over the lamps for drying after being washed. These cathodes are cheap, simply and quickly made, and with the exception of requiring cleaning in bright dip at least every second plating, are very satisfactory.

The immersion area was calculated to be about 100 sq.cm. This particular gauze was adopted after a series of experiments with various sizes and mesh had shown that this was the best, having sufficient rigidity, convenient weight (about 12 g.), and withstood the cleaning operations better than the others. For anodes strips of platinum foil 0.2 in. wide and 0.001 in. thick were used.

Speeds of rotation of about 500 per min. were used. As the tops of the gauze electrodes are set at the level of the electrolyte, any tendency to mount up the sides is counteracted and no splattering or throwing of the solution occurs. Table I gives the results of tests using 3 amp. current and a voltage drop of 3.7 per cell.

TABLE I

Time, Min.	Copper Deposited, Grams	Copper in Solution, Grams	Temperature of Electrolyte, Deg. C.
0	0.0000	0.9981	19
5	0.3231	0.6750	23
10	0.6252	0.3729	
15	0.8952	0.1029	
20	0.9904	0.0077	
25	0.9971	0.0010	
30	0.9979	0.0002	
34	0.9982	0.0001	
35	0.9980	0.0001	40
36	0.9981	0.0000	
40	0.9980	0.0001	
50	0.9981	0.0000	
60	0.9981	0.0000	

To confirm the completeness of deposition as indicated by weighing, the depleted electrolytes were tested colorimetrically with a saturated solution of hydrogen sulphide water, against equal volumes of solution of the same acid concentration as the electrolyte, and containing 0.002 per cent copper. The usual spot plate test was found to be not sufficiently delicate. Tests after 34 min. plating time showed complete deposition of copper, though not indicated by the balance sensitive to 0.00005 milligram. The first wash waters were similarly tested, and in no case where complete deposition was indicated by the balance was any copper found in them.

Table II gives the results using 6 amp. current and voltage per cell of 4.1, also at 9 amp. and 4.9 volts.

TABLE II

Amperes	Time Min.	Copper Deposited, Grams	Copper in Solution Grams	Temperature of Electrolyte, Deg. C.
6	0	0.0000	0.9984	19
	5	0.6235	0.3759	
	10	0.9372	0.0612	
	15	0.9960	0.0024	51
	21	0.9977	0.0007	57
	25	0.9982	0.0002	
	26	0.9984	0.0000	
	30	0.9984	0.0000	63
	35	0.9983	0.0001	67
9	0	0.0000	0.9984	19
	15	0.9983	0.0001	
	16	0.9985	—0.0001	
	17	0.9984	0.0000	71

The deposits of copper without exception were a beautiful pink, satiny, adherent, and firm. These tests show the capability of the apparatus in rapidly plating these large amounts of copper quantitatively, showing that with 3, 6 and 9 amperes the amounts taken are plated in approximately 35, 26 and 16 min., respectively, within very close limits of experimental error. The curves in Fig. 7 show the results plotted from Tables I and II.

This apparatus is ideal for plating the copper of brasses and alloys, allowing of assured deposition on 1 g. in 40 min. with 4 amperes, though 30 min. is usually sufficient. Unknown brasses *A*, *B*, and *C* were analyzed for copper. To overcome the difficulty of selecting representative 1-g. samples, 10 g. were taken, treated with 25 cc. nitric acid and water 75 cc. to end of brown fumes, 35 cc. sulphuric acid was added and heated until

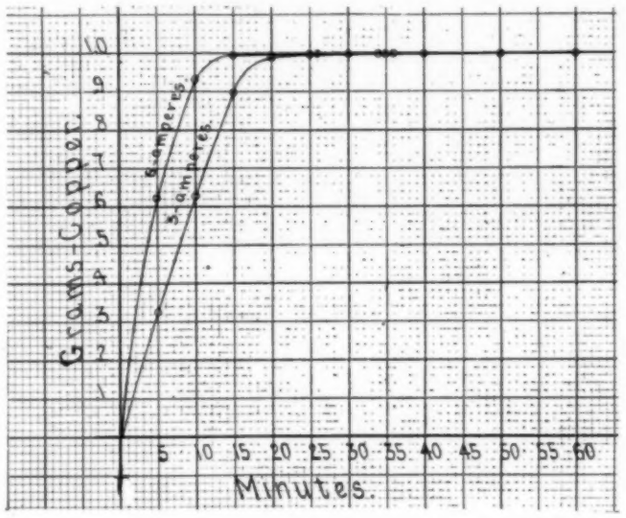


FIG. 7. CURVES SHOWING RESULTS AT DIFFERENT CURRENTS

all the copper was in solution, diluted, filtered and filter washed. The filtrate and washings were brought up to 500 cc. with water; 50 cc. aliquots pipetted, 15 cc. potassium nitrate and 25 cc. water were added in beaker. Electrolysis was continued 40 min. with 4 amp. current. Table III gives the results of the work on brasses, also the results on the same brasses by other operators on this and other stirred electrolyte apparatus.

TABLE III

Brass	Operator	Apparatus	Copper, Per Cent
Drillings A	W	Magnetic stirring	61.31
	B	" "	61.36
	G	" "	61.20
	G	" "	61.20
	Mc	Rotating cathode	61.30
	H	Air stirred	61.12
	K	King	61.33
	K	"	61.36
	K	"	61.35
Drillings B	D	Rotating cathode	62.82
	R	Dish cathode	60.68
	K	King	62.90
	K	"	62.83
	K	"	62.85
Cuttings C	F	King	67.64
	F	"	67.65
	K	"	67.59
	K	"	67.60
	K	"	67.56

The apparatus has been thoroughly tested in two laboratories of this university, and has been subjected to the rigors of constant use in a commercial laboratory for over a year, working on the determination of copper and lead in alloys and ores, where it has given excellent satisfaction in every respect.

SUMMARY

Electro-analytical methods using still and stirred electrolytes are discussed.

Results of experimental work with apparatus employing both principles are given and explained.

An apparatus of new design, exhibiting a new method of agitating the electrolyte (stirring by rotating the containing beaker) is described, together with preliminary apparatus leading to the adaption of the apparatus in its final form.

The operation of the apparatus and the method of carrying out an analysis are given in detail.

Tests carried out with the view of determining the accuracy and speed of the new apparatus are described and results tabulated.

A table showing results of experiments on three different brasses, obtained by this and other methods of stirring and carried out by different operators, is included.

In conclusion the writer wishes to express acknowledgment of his appreciation for many helpful suggestions from the staff of the Department of Mining Engineering and to Mr. J. T. Burt-Gerrans of the Electrochemical Department for data furnished, and tests made.

American Zinc Institute Meeting

DURING the war, zinc production was stimulated to such an extent that, at the present time, the producing capacity is much in excess of the normal demand. In view of this condition, it is not surprising to find the attention of the members of the American Zinc Institute centered upon the development of new uses for zinc.

At the annual convention of the Institute held at St. Louis on June 9 and 10, George C. Stone, of the New Jersey Zinc Co., presented a summary of the advantages offered by sheet zinc for building work, roofing, gutters, leaders, flashing, cornices and other architectural materials. This field appears to be the most promising outlet for large tonnage surplus. The Institute was urged to start an educational campaign similar to that carried out by the Vieille Montagne Co., which resulted in the recognition of the value of sheet zinc in Europe. In endeavoring to find new uses for zinc, it must be remembered that this metal possesses certain limiting qualities, such as: its low strength, high thermal expansion (about double that of iron), the tendency of wrought zinc to recrystallize and become brittle at relatively low temperatures, also that it is attacked by both acids and alkalis and it can be ignited at a much lower temperature than any of the other common metals.

Other Speakers

The subject was discussed further by E. H. Wolff, of the Illinois Zinc Co., and George S. Harney, of the American Zinc Products Co. Mr. Wolff emphasized the fact that the durability of zinc roofs is not generally appreciated by architects. Mr. Harney urged the elimination of such misnomers as spelter, jack, galvanizing and sheradizing and the substitution of terms containing the word zinc. As a result, a recommendation that "zinc" be substituted for "spelter" in all quotations, specifications and contracts and also "zinc plate" for "galvanized iron," was passed unanimously. Provision was also made for the appointment of a publicity committee to request the Government statisticians, trade journals, the Associated Press and newspapers to make these substitutions in their reports.

The presentation of these papers was followed by a lively discussion on the part of the other members of the Institute, and resulted in the board of directors setting aside a considerable amount of money to advance this work. In this connection the plans of Dr. John Johnston, who during the war was an active member of the National Research Council, were referred to the proper committee for a prompt report to the board of directors.

Annual Dinner

The annual dinner at the Hotel Statler was largely attended. Dr. W. F. Gephart, dean of finance and economics at Washington University, St. Louis, acted as toastmaster, and Edward Gengenbach, industrial commissioner of the St. Louis Chamber of Commerce, spoke on "Confidence and Progress." Pope Yeatman, at whose suggestion the Institute was formed, journeyed from New York to St. Louis to meet his old friends in the zinc world, and to talk to them on the "Influences of the War on the Zinc Industry." The speeches of the evening dealt with present and future conditions in the business world, the dominant note being "Forward, March!" The members voted to ask George C. Stone to make, in person, in the interests of the Institute, a survey of zinc conditions in Europe. Mr. Stone expects to sail early in July.

Interesting Papers Read

Among the other interesting papers read at the meetings were the following: "Some Causes of the Unsound Economic Position of the Zinc Industry in the United States," by William A. Ogg, president American Zinc, Lead & Smelting Co.; "Tri-State Mining and Production," by Otto Ruhl, C.E., Joplin, Mo.; "Mining and Production in Wisconsin," by A. M. Plumb, Wisconsin Zinc Co.; "Production of Zinc in the Southeastern States," by J. N. Houser, vice-president American Zinc, Lead & Smelting Co.; "Early Days of the Industry," by C. E. Siebenthal, of the U. S. Geological Survey; "Mines Taxation," by R. C. Allen, director, Geological and Biological Survey, Michigan. An interesting moving picture lecture on "Safety Lessons in Metal Mining" was given by B. F. Tillson at the close of the Monday meeting. The badges worn by members were made of zinc and a diversified exhibit of new uses for zinc was displayed at the unique registration booth of the Institute in the corridor of the Hotel Statler.

A budget of $20,000 to forward the aims of the Institute was approved by the members, which now number nearly 200, and the following officers and directors were elected:

Officers

Term expiring 1920: President, Charles T. Orr; first vice president, Edgar Palmer; second vice president, James L. Bruce; third vice president, F. C. Wallower; treasurer, Howard I. Young; secretary, Stephen S. Tuthill.

Board of Directors

Term expiring 1920: George O. Argall, Joseph Brennemann, Arthur Thacher, C. M. Loeb, Edward M. McIlvain, George E. Nicholson, F. C. Wallower; term expiring 1921: J. H. Billingsley, P. B. Butler, Julius W. Hegeler, Cornelius F. Kelley, William A. Ogg, Edgar Palmer, O. S. Picher; term expiring 1922: James L. Bruce, A. P. Cobb, A. S. McMillan, Charles T. Orr, Victor Rakowsky, Wm. F. Rossman, E. H. Wolff.

The next meeting of the Institute will be held in Chicago on the second Monday in May, 1920.

Treatment of Complex Speisses*

Description of Recent Research on the Treatment of Complex Speisses and the Application of the Results to Commercial Metallurgical Processes—Proposed Method of Treating With Pyrites in an Electric Furnace

BY PAUL PAPENCORDT
Translated by Oliver C. Ralston

AMONG the many intermediate products obtained in metallurgy which make it difficult to prepare pure metals direct from the ores, the speisses are perhaps the most troublesome because the recovery of the valuable metals from them is attended with unusual difficulty. It is not many years since speisses were discarded even by large smelters. In those smelters where speisses are treated the methods are tedious and often expensive. The purpose of this work was to devise a simpler process not subject to the excessive losses now suffered by smelters.

The speiss on which the tests were made came from the copper smelter at Oker-a-H. Its composition was as follows:

	Per Cent.		Per Cent.
Cu	23.50	Ni+Co	2.90
Pb	16.30	Zn	3.10
As	12.20	S	2.10
Sb	13.20	Au+Ag	0.12
Fe	26.20		

Just how far the constituents of such a complex are chemically united and how much they are in solution in each other is difficult to determine. Among the binary systems of various elements with arsenic or antimony which have been studied we find the following described by Friedrichs in the volumes of *Metallurgie* from 1905 to 1908:

In the system copper-arsenic there are two chemical compounds, Cu_3As and Cu_5As. However, the arsenic is only loosely bound in the copper-arsenic alloys. Alloys high in arsenic lose most of it by merely standing in powdered form in a space heated to 300 deg. C. or higher.

In the system iron-arsenic the following compounds are found: Fe_2As, Fe_3As_2 and apparently FeAs. The compound Fe_2As forms a eutectic with arsenic which freezes at about 830 deg. C., but it forms mixed crystals with Fe_3As_2 if cooled quickly. The compound Fe_3As_2 is the product of a reaction which takes place at about 800 deg.

In the system nickel-arsenic there are two compounds, NiAs and Ni_5As_2. The existence of NiAs is well proved, but that of Ni_5As_2 is doubtful. Nickel-arsenic alloys have not hitherto been roasted and refined with much success.

In the system iron-antimony are two compounds, Sb_3Fe_3 and Sb_2Fe. In the system cobalt-arsenic are Co_2As_3, Co_2As and Co_5As_2.

The main object to be obtained is to eliminate the arsenic and antimony from these speisses. In practice this is done by roasting either the molten or non-molten material, and a strong blast of air is passed either through or over it so that more or less of the arsenic and antimony are removed as volatile oxides. For instance, the process used at the copper smelter in Oker-am-Harz consisted in treating speiss in the so-called speiss-furnace by the "blast-process." This furnace had water-cooled top and bottom. The side walls, arch, fire-bridge and flue gas ports were of firebrick. The hearth was built in three layers. On the iron bottom was laid a layer of tamped marl covered with the layer of firebrick. This was made of a mixture of 20 parts of slate splinters with 80 parts of crushed marl. The furnace was fired by simple reverberatory firing with under-draft. The excess air for oxidation was led in through two nozzles. The refining or 'blowing' process took place in the following manner: After the charge had been placed in the furnace all openings were luted shut and the temperature was raised to a glowing red. Several hours were allowed at this temperature for the roasting. Then the temperature was raised suddenly, compressed air turned on and the charge allowed to melt and the dross to separate. First the iron oxides and slags with the hearth; then the antimony and lead oxidize and enter the iron silicate slag, making it very basic. The greater portion of the arsenic can be volatilized only after these elements have been slagged, and during this stage the temperature of the furnace can be so lowered that the contents of the furnace become quite pasty. The removal of the arsenic is indicated by the cessation of fumes, after which the firing is increased again and the concentration of the speiss has been accomplished.

ANOTHER PROCESS

Another interesting process for the working of speisses is given by Guillemain in *Metallurgie*, 1910, 598. Here the speiss-bath was blown with dry chlorine gas. The antimony and arsenic were removed very well, but the process proved too expensive. Guillemain later directed his attention to cheapening the ordinary dearsenification methods. He used blast-roasting methods similar to those used in the Savelsberg and the Huntington-Heberlein processes for lead ores. The groud speiss was mixed with difficultly-fusible material like limestone, or acid slag, and either preheated before placing in the blast pots or only partially heated before filling the pots in the regular manner. By blowing to a glowing red most of the arsenic and antimony volatilized as As_2O_3 and Sb_2O_3.

*Translated from *Metall und Erz*, 16: 6-13 (1919). This paper was given as a communication from the Institut für Metallhüttenwesen und Elektrometallurgie der Kgl. Techn. Hochschule Aachen, and gives the results of some tests on the treatment of complex speisses which could only be carried out on a small scale, due to war conditions. The suggestions embodied in the paper have great promise of solving more satisfactorily the treatment of such undesirable complexes as are met in the speisses of some copper smelters. Pure arsenic sulphide is sold as a rather expensive pigment which has mostly been produced in Germany until war conditions shut off the supply. If any German smelters start using this method of working up their complex speisses they will be able to undersell manufacturers of arsenic sulphide as it is made at present in the United States.—[TRANSLATOR.]

All of these processes give a mixture of metal oxides which are by no means free of sulphides of arsenic and antimony. A glance at the voluminous literature on beneficiation of such products is sufficient to show that the treatment of these mixtures is attended with great difficulties. No process has ever been in the least satisfactory. The process of Schilowski, developed at the Institut für Metallhüttenkunde und Elektrometallurgie der Königliche Technischen Hochschule zu Aachen, (see *Metallurgie*, 8, 617, 1911), for electric smelting of copper ores containing arsenic, seemed to offer the best chances of success. In this process the arsenic was completely volatilized as a sulphide and condensed in a small condenser. As to whether antimony could be similarly removed, only tests could tell.

These tests relied on electric melting with exclusion of all air combustion gases. The melting of the speiss was performed in a graphite crucible into which projected two carbon electrodes, forming an arc furnace (see Fig. 1). A hole was bored into the bottom of the

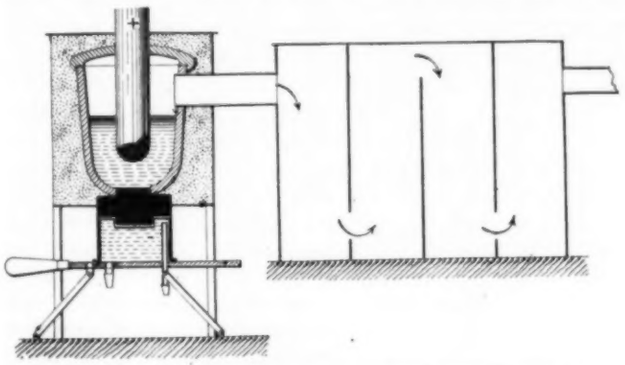


FIG. 1. FURNACE IN WHICH TESTS WERE MADE

crucible and a carbon electrode fitted in, while the others were introduced through corresponding holes in the cover. The bottom of the crucible was covered with tar and the side was fitted with a suitable delivery tube leading into an iron box condenser which was divided into a number of compartments. This box served to condense the sublimed products and the opposite end was connected to a ventilating chimney to dispose of any gases.

The speiss contained only 2.1 per cent sulphur, and it was therefore necessary to add enough to form sulphides with the arsenic and antimony. Pyrite seemed to be the best addition agent. A sample of pyrite containing 35.1 per cent sulphide was used. In order to convert the other metals into sulphides it was necessary to add the following amounts:

		Per Cent.			Per Cent
Cu	into Cu_2S	6.0	Co-Ni	into $(CoNi_2)S_2$	1.5
Pb	into PbS	2.0	Zn	into ZnS	5.0
As	into As_2S_3	7.5			
Sb	into Sb_2S_3	5.0		Total	38.5
Fe	into FeS	15.0			

Since the speiss contained 2.1 per cent sulphur, 36.4 per cent sulphur had to be added. In these tests, therefore, the speiss and pyrite were both powdered and mixed and then melted together in the furnace, with exclusion of air. Each test took 20 minutes.

TEST 1

A charge of 1 kg. speiss with 0.5 kg. pyrite was melted. In a very few minutes after turning on the current brown fumes poured out of the outlet of the condenser. The color and smell indicated arsenic sulphide. The evolution of the arsenic sulphide was so fast that the condenser proved to be too small for complete condensation of the arsenic sulphide.

The results of this test were: a speiss which had settled to the bottom; copper matte, a glassy slag and a sublimate. Analysis gave:

Matte:	Per Cent	Antimonial Speiss:	Per Cent
As	0.11	As	0.27
Cu	25.8	Cu	7.96
Sb	0.15	Sb	17.94

Copper Balance

Charge contained: 1000 g. speiss with 23.5 Per Cent Cu = 235 g. Cu

Products contained:

685 g. matte	with 25.8 Per Cent Cu =	176.0 g. =	74.89 Per Cent
725 g. speiss	with 7.96 Per Cent Cu =	57.7 g. =	24.57 Per Cent
220 g. slag	with 0.17 Per Cent Cu =	0.4 g. =	0.15 Per Cent
	Loss,	0.9 g. =	0.39 Per Cent
	Total,	335 g.	

TEST 2

In this case 1 kg. of speiss was melted with 1 kg. of pyrite in the same manner as in Test No. 1, and enough sulphur was present to convert all the metals into sulphides. It lasted 20 min. and the products again were matte, speiss, slag and sublimate.

Matte:	Per Cent	Speiss:	Per Cent
As	0.0	As	0.08
Cu	26.2	Cu	3.66
Sb	0.03	Sb	16.52

Copper Balance

Charge contained: 1000 g. speiss with 23.5 Per Cent Cu = 235 g. Cu

Products contained:

780 g. matte	with 26.2 Per Cent Cu =	204.36 g. =	86.96 Per Cent
790 g. speiss	with 3.66 Per Cent Cu =	28.82 g. =	12.22 Per Cent
250 g. slag	with 0.21 Per Cent Cu =	0.52 g. =	0.27 Per Cent
	Loss	1.3 g. =	0.55 Per Cent
	Total	235 g.	

TEST 3

In this test 1 kg. of speiss was melted with 1.5 kg. of pyrite, meaning an excess of sulphur, but again there were matte, speiss, slag and sublimate.

Matte:	Per Cent	Speiss:	Per Cent
As	0.0	As	0.02
Cu	28.3	Cu	4.15
Sb	0.031	Sb	16.8

Copper Balance

Charge contained: 1000 g. speiss with 23.5 per cent Cu = 235 g. Cu

Products contained:

710 g. matte	with 28.3 Per Cent Cu =	200.93 g. =	85.15 Per Cent
780 g. speiss	with 4.15 Per Cent Cu =	32.37 g. =	13.70 Per Cent
280 g. slag	with 0.23 Per Cent Cu =	0.60 g. =	0.20 Per Cent
	Loss	1.10 g. =	0.40 Per Cent
	Total	235 g.	

From these three tests it could be seen that in all three cases there was obtained a copper matte containing only traces of arsenic, a speiss free of arsenic but rich in antimony, a slag and a sublimate. Also most of the copper could be converted into a matte. A small amount of arsenic in the matte of Test 1 was due to deficiency of sulphur. Still the matte contained on an average 85 per cent of the copper and the remainder insisted on staying in the antimony speiss. In the speiss nearly all of the original antimony was present. This was confirmed by analysis of the sublimate.

Four more tests were made to see if a longer time in the furnace would cause the antimony to volatilize as Sb_2S_3. Test 4 lasted 25 min., Test 5 lasted 30 min., Test 6 lasted 40 min. and Test 7 lasted 50 min. The results scarcely varied from those already reported.

CONCLUSIONS

It therefore seemed safe to conclude that by melting a speiss in an electric furnace with pyrite and with exclusion of air there can be obtained:

(*a*) Copper matte, free from arsenic, containing most of the Cu.

(*b*) Antimony speiss, free from arsenic, containing the remaining Cu.

(*c*) Barren slag.

(*d*) Arsenic sulphide sublimate.

The arsenic of the original speiss was almost completely volatilized, while the antimony was almost completely recovered in the new speiss. That most of the arsenic was also in the sublimate was later confirmed by analysis, and it also contained very little antimony. Most of the original speiss had been converted into a leady copper matte, the subsequent treatment of which will be mentioned later.

Tests on the New Speiss

The new speiss still contained enough copper to make another operation for the recovery of this copper necessary. It is well known that antimony sulphide is soluble in water solutions of alkali sulphides forming sulphantimoniates. The new speiss was pulverized, mixed with coal and sodium sulphate and heated in a Helberger crucible furnace in order to convert the antimony of the speiss into sodium sulphantimoniate. The reaction is:

$$Sb_2S_3 + 3Na_2SO_4 + 6C = 2Na_2SbS_3 + 6CO_2$$

The fused mass was allowed to cool, pulverized and leached with hot water in a rotating glass barrel which was kept heated by bunsen burners. The results of the tests were as follows:

Test	Speiss Leached	Time, Hr	Water, cc.	Antimony Dissolved, g.	Per Cent
1	100	1	1000	12.13	73.00
2	100	2	1000	14.78	89.00
3	100	3	1000	16.43	99.45
4	100	4	1000	16.45	99.58
5	100	5	1000	16.48	99.75

These tests showed that the leaching of practically all of the antimony took place in 3 hr. and that only traces were extracted by longer leaching. The residue contained the copper, lead and iron as sulphides, together with the precious metals, and could be combined with the copper matte to be treated by standard methods. The fact that the antimony in the speiss was soluble in water as Na_3SbS_3 makes it possible to isolate it as a by-product which can be converted either into antimony pigments or into metal. Some iron sulphide seems to dissolve, imparting a turbidity to the solution. Metallic antimony can easily be obtained by electrolysis of this solution.

To test this latter process an accumulator jar was used for electrolytic bath with lead sheet anodes and sheet iron cathodes. A tension of 2 v. was used, and in order to prevent precipitation of iron with the antimony some common salt was added to the electrolyte. At the end of the electrolysis the antimony was present on the cathodes as gleaming plates. The solution electrolized originally contained 8.21 g. of antimony and the weight of deposited metal was 8.21 g. Hence the loss of antimony is very small, and the earlier work of Borchers (Lehrbuch der Elektrometallurgie) has shown that the electrolysis is very simple.

Treatment of the Sublimate

In these tests the sublimate from the original Test 2 was used. In this test 210 g. of sublimate with an arsenic content of 45.3 per cent had been obtained, and it was also found that it contained 0.47 per cent Cu. The original charge of 1 kg. speiss had contained 121 g. arsenic, and the 210 g. of sublimate contained only 95.13 g., showing that 25.87 g. had been lost. This corresponded to a recovery of 78 per cent. The arsenic was present as As_2S_3 and in order to be obtained pure from sulphides of copper, iron, lead and zinc it had to be resublimed at a temperature of 700 deg. C.

A lot of 50 g. was heated between 700 and 800 deg. with exclusion of air and a brown vapor passed over into a water-cooled condenser. The 50 g. of material tested contained 22.6 g. arsenic and the sublimate contained 35.2 g. with 59.8 per cent As, or 20.79 g. arsenic, meaning a recovery of 92 per cent of the arsenic. This was done in a carbon crucible and there remained a residue of copper, nickel, iron and arsenic. This residue could be treated with the original speiss in practice.

Analysis showed that the resublimed arsenic contained no impurities except some free sulphur. In practice such a pure product might be difficult to obtain with a single resublimation, but it could be resublimed.

Treatment of the Copper Matte

The arsenic-free copper matte contained a great deal of lead as well as some nickel and cobalt, and the same was true of the residue from the antimony leaching. Rauschenplat has shown (*Metallurgie* 7:154, 1910) that the lead can be slagged away from the copper very easily by forming a siliceous slag. Therefore part of the matte was pulverized, mixed with silica and dead-roasted in a muffle until sintering commenced. This was then mixed with some unroasted matte and more silica and melted in an electric furnace, sketched in Fig. 2, to allow the reaction process to take place.

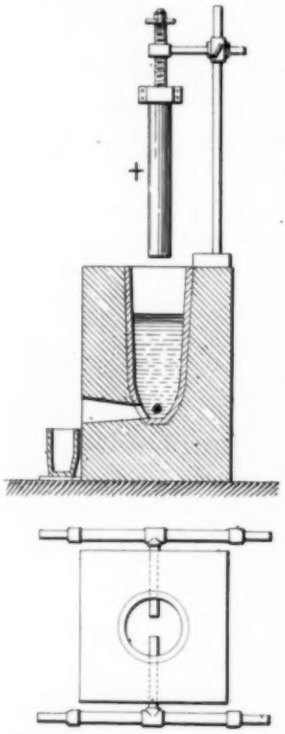


FIG. 2. ELECTRIC FURNACE IN WHICH THE COPPER MATTE IS TREATED

The result was a black copper metal containing the precious metals and nearly all of the nickel and cobalt, while the slag contained the iron and practically all of the lead in the form of silicates. The copper contained 92.4 per cent Cu, 6.7 per cent Ni and Co, and 0.25 per cent Fe. This product can enter the commercial copper-refining processes, especially the electrolytic refining process, which recovers all the metals mentioned. No tests were made, since it is known that it is possible to make cathode copper, anode slime containing the precious metals, and the nickel and cobalt enter the electrolyte. The lead silicate slag can also be treated by the roast-reduction process to form work-lead, a process which is standardized.

Summary

The method of treatment of the speiss will therefore be: Melting in the absence of air and with the addition of pyrite in an electric furnace, whereby the volatile products can be conducted away and condensed. The products obtained are:

1. Arsenic-free copper matte with traces of antimony, but containing at least 80 per cent of the copper con-

tent of the speiss. The copper content of the matte amounts to 25 per cent.

2. Antimonial speiss with traces of arsenic and up to 4 per cent Cu, which amounts to about 20 per cent of the total copper content of the original speiss.

3. Sublimate, consisting essentially of arsenic sulphide but contaminated with small amounts of sulphides of copper, iron, lead and zinc.

The copper matte is mixed with silica and dead-roasted, followed by smelting with unroasted matte, giving copper metal which contains the precious metals and the nickel and cobalt.

The antimonial speiss is powdered, mixed with sodium sulphate and coal and melted. The melt is leached with hot water to form a solution of Na_3SbS_3 and the residue, containing copper, lead, nickel and cobalt sulphides with traces of precious metals, is worked up with the copper matte. Metallic antimony is thrown out of the solution by electrolysis.

The sublimate is resublimed at about 700 deg. C. forming arsenic sulphide, which finds direct commercial application. Nearly all other processes of treating speisses do not recover the arsenic and antimony in the form of easily marketed by-products.

Commercial Application of the New Process

It is now possible to outline the fundamentals of a new metallurgical treatment of speisses. The proposal was to melt speisses with pyrite in an electric furnace, but in practice it would be more profitable to use cupriferous pyrite or pyrite containing precious metals. Only a carbon-lined electric furnace seems proper for the melting and in order to prevent the corrosive action of the molten speiss it would be best to water-cool the bottom and the bottom third of the side walls. Since metallurgical speisses are ordinarily formed in a molten state, they should be collected in a fore-hearth in the copper smelter and then fed into the electric furnace in the molten state. Here the pyrite is added in the calculated proportion, the furnace closed air tight and the current of electricity passed for a time. Only a small energy consumption need be met in the furnace and the only doubtful point is whether the pyrite and speiss get thoroughly mixed. The liquid contents of the electric furnace are then tapped out.

The new antimonial speiss, by virtue of its high specific gravity, is found on the bottom of the furnace and is tapped first. It is ground, mixed with sodium suphate and coke, and placed in a preheated smelting furnace, whereby the antimony is converted into sodium sulphantimoniate. The contents of the crucibles are poured out. Any floating matte is removed and worked up later. The melt is cooled and pulverized and leached with hot water.

Leaching apparatus should consist of iron vats with conical bottoms and steam inlets to warm and stir their contents. Other settling tanks are needed and slime-filters to separate the solution from the residue of copper, lead, iron, etc. The solution should be electrolyzed according to Borchers' process. (See Borchers' "Elektrometallurgie.")

The antimony electrolysis installation should consist of a series of vats in cascade. The baths will be rectangular iron vessels in which are hung alternately sheets of lead and of iron as anodes and cathodes. The vessel also forms a cathode. Since the solution becomes specifically lighter during electrolysis, the liquor must flow into the bottom of each cell and overflow from the top. The current density must fall with the antimony content of the solution. About 100-150 amp. per sq.m. is all right at the beginning, but toward the end only 40-50 amp. per sq.m. can be used. This can be done by building baths progressively longer. The antimony scales or powder stick in part to the iron cathodes and part falls to the bottom of the cells. Since the solution contains some iron, the deposited antimony contains some iron, and this must be removed during the melting of the antimony by adding antimony sulphides to the metal or by adding some common salt. The leach liquor is oxidized by air and concentrated until sodium hyposulphite crystallizes out. This is an article having a wide market.

Passing to the treatment of the crude sublimate, it was found that the red color was due to the presence of As_2S_3, and in separating from the other metal sulphides it is necessary to resublime it in a Freiberger subliming furnace. This consists of three tiers of 12 clay retorts, each of which are about 1.5 m. long and 12 cm. in diameter (4.5 ft. x 5 in.). The material is introduced into the back ends of the retorts, and these are heated to a dull red glow. After carrying out the sublimation the residue is taken out and added to the next charge of speiss that is melted in the electric furnace with pyrite. The sublimate which collects in the condenser is the arsenic sulphide of commerce.

The treatment of the copper matte should be as follows: The matte is pulverized, mixed with the cupriferous residue of the antimony leaching and with silica, and roasted either in a stationary furnace or a revolving roasting furnace. The temperature will be held at such a point that incipient sintering takes place. The roasted material is then mixed with unroasted matte in the proper proportion and treated in a shaft furnace, forming metallic copper containing cobalt, nickel and the precious metals. This is an article of commerce, or it can be electrolytically refined. The lead from the matte passes into a silicate slag from which it can be smelted by standard processes, forming work-lead.

Spelter Production in United States

The Department of the Interior, by the United States Geological Survey, reports as follows on spelter produced in the United States, during 1917-18.

	Short Tons	Average Price per Lb.	Short Tons	Average Price per Lb.
Illinois	172,489	.....	141,844	.....
Kansas	76,048	.....	29,149	.....
Oklahoma	204,394	.....	139,066	.....
Pennsylvania	86,995	.....	77,342	.....
Other States	104,438	.....	91,610	.....
Electrolytic	25,209	.....	38,916	.....
Total primary	669,573	.....	517,927	.....
From domestic ore	584,597	.....	492,405	.....
From foreign ore:				
Australia	26,140	.....	1,780	.....
Canada	6,787	.....	8,700	.....
Chile	.....	.....	886	.....
Italy	2,951	.....	113	.....
Mexico	40,360	.....	14,043	.....
Spain	8,738	.....	.....	.....
Total foreign	84,976	.....	25,522	.....
Total primary	669,573	.....	517,927	.....
Redistilled secondary	16,835	.....	9,597	.....
Total	686,408	.....	527,524	.....
Grade A	97,707	14.0c.	129,023	11.1c.
Grade B	69,189	12.7c.	68,987	10.7c.
Grade C	148,749	9.4c.	98,584	8.0c.
Grade D	370,763	9.0c.	230,930	7.9c.
Total	686,408	10.2c.	527,524	9.1c.
Total value	$140,027,000		$96,009,000	

Manufacturing Plant of the Providence Gas Co.—I

Review of the Development of the Gas Industry in Providence, R. I.—Description of the Plant as It Was Before the Installation of the Koppers Combination Gas Ovens

BY WALTER M. RUSSELL*

THE City of Providence, Rhode Island, U. S. A., is located at the head of Narragansett Bay, about thirty miles from the open ocean. The city proper has an area of something over 18 sq.m. and a population within this area of about 250,000. As a seaport, it ranks tenth in the United States in bulk of tonnage and value of cargoes, having direct connection by water with Philadelphia, Baltimore, Norfolk and Mediterranean ports. It is the leading oil port of New England and with the completion of a new 30-ft. channel will have one of the best harbors in the world.

Providence is a great manufacturing city, being first in the country in the manufacture of jewelry and silverware, also having the largest mechanical tool factory, file factory, engine factory, screw factory and silver factory in the world. It is surrounded by the greatest textile districts of the country.

Gas is supplied to the city proper, also to Olneyville, cities and towns of North Providence, East Providence, Cranston, Riverside, Barrington, Warren and Bristol, serving in all about 65,000 consumers, utilizing some 450 miles of mains.

Being the center of a great industrial section and known as the "southern gateway" of New England, it is the logical point for the distribution of gas and coke to industries requiring these commodities.

The Providence Gas Co. first commenced operations in the year 1848. A coal gas works was erected on the east side of the Narragansett Bay and became known as the East Station. This gas works continued in operation until the year 1870, at which time the output of gas was about 132,000,000 cu.ft. per year.

In 1870 a new gas works was built on the west side of the Bay, called the West Station. This plant was considered a model for its time and it was in this works that some of the first recuperative benches in the United States were successfully operated. Coal gas only was made in this plant until the year 1891, when water gas sets were installed.

In 1877 the Citizens Gas Co. began operations in opposition to the Providence Gas Co. During the '70s there was a great deal of activity in the United States on the part of opposition gas companies. These were usually organized by promoters for the purpose of putting up a plant which would later have to be bought out by the established company at a profit to the promoter. As a rule, these companies put up cheap water gas plants, but in this case there was an exception, as the Citizens Gas Co. built a coal gas plant which was purchased by the Providence Gas Co. in the year 1878 and became known as the South Station. In 1890 water gas sets were built in this works. The West Station then became known as the North Station, and these two works, the North Station and the South Station, continued in active operation, making coal and water gas, until 1911.

THE SASSAFRAS POINT STATION

Between 1900 and 1906, the output of gas increased 50 per cent and in 1905 it became evident that the capacity of these stations would soon be exceeded; also both the North and the South Station were situated where adjoining land was extremely expensive to purchase and the land already owned was so closely covered with buildings as to allow of no further expansion. It was, therefore, determined to plan for the future, and 40 acres of land were purchased situated about two miles southerly from the town, bordering on Narragansett Bay and having a railroad connection with the New York, New Haven & Hartford Railroad. During the next four years, many plans were carefully considered, which culminated in the construction of an entirely new coal gas plant at the new site, which became known as the Sassafras Point Station.

In 1910 the North Station was abandoned and the following year, with the starting of the new coal gas plant at the Sassafras Point Station, coal gas was discontinued at the South Station, it being continued only as a water gas plant. The output for the year 1910 was 1,386,819,000 cu.ft.

In January, 1909, a contract was let to the Didier-March Co. to build a retort house complete from the coal crusher to the coke storage bins; the retort house to be capable of housing four batteries of retorts, two only being built at first. These batteries each consisted of six benches, containing ten retorts, making 120 retorts in the first installation. This was followed by a third battery of 60 retorts in 1911, and in 1912 a fourth stack was built of six benches each, containing 15 retorts; so that the total capacity of the house was 270 retorts. The construction of the coal handling equipment, condensing and purifying buildings and equipment and the meter house and power house equipment was done by the Bartlett Hayward Co.

Ground was broken April 1, 1909, and the first gas was made in October, 1910. The system of coal carbonization adopted was the Dessau vertical retort slightly modified to meet American conditions. The plant as finally completed had a nominal daily capacity of 3,200,000 cu.ft., and was in operation until January, 1919, when the retorts were abandoned and a battery of 40 Koppers combination gas ovens were turned on.

ALL MANUFACTURING PLANTS COMBINED

In 1916 a new water gas plant was built at Sassafras Point and all manufacturing was abandoned at the South Station, thus bringing all the manufacturing

*Read before the American Institute of Chemical Engineers, Cambridge, Mass., June 20, 1919.

plants together at one works. In 1905 a 4,000,000-cu.ft. holder was built near the South Station. In 1911 a 6,000,000-cu.ft. holder was built at Sassafras Point and in 1915 a 3,000,000-cu.ft. holder was built in a suburb of Providence for reinforcing the supply in that district. All holders were built by the Bartlett Hayward Co. and are telescopic holders contained in steel plate tanks on concrete foundations.

During 1917 it became apparent that the vertical retort plant had reached the end of its useful life, and various plans were considered for replacing it with coal carbonizing equipment. It was finally decided to build a battery of 40 Koppers combination gas and coke ovens, which would give a nominal generating capacity of 7,000,000 cu.ft. per day, capable of making at least 10 per cent more gas than their rating, if desired. The construction of this plant was started early in 1918 and gas was first made the latter part of January, 1919.

At the present time the Providence Gas Co. is equipped with a water gas plant which can easily generate 9,000,000 cu.ft. of gas per day and with a coal plant generating up to 7,750,000 cu.ft. per day. As the present output is in the neighborhood of 2,250,000,000 annually, with a maximum daily output of 9,300,000, it would appear that no further extensions of the plant should be necessary for years to come.

All buildings and practically all apparatus now used in generating gas were new within the last ten years and represent in every respect the most up-to-date and modern practice in the United States. It is proper to say that the Providence Gas works is the model gas plant of New England, if not of the United States.

Coal Gas Works of 1910

The first plant to be erected at Sassafras Point was the Dessau vertical coal gas works, which was built under the supervision of the gas company's engineer, Mr. Carroll D. Miller, who has described the construction and operation of this plant in papers before the New England Association of Gas Engineers and also the American Gas Institute, from which papers I have liberally drawn for the information given herewith.

Coal Storage Plant

A sea wall of stone masonry was constructed and has since been extended to be about 600 ft. long, and there is a depth of about 28 ft. of water at high tide, which will accommodate all ordinary coal barges and some of the large capacity steamers. For unloading coal from barges and delivering to the storage pile or storage shed, a coal bridge (Fig. 1) was erected by the Brown Hoisting Machinery Co. This coal bridge has a capacity of 100 to 150 tons per hr., depending on the conditions. Coal is picked up with a 2-ton clamshell bucket. One leg of the coal bridge runs on the sea wall, the other leg on rails close to the coal shed, with a 211-ft. span. The trolley handling the clamshell bucket has a travel of 304 ft. and the total length of the bridge is 324 ft., including overhang. The clearance of the bucket from the ground is 56 feet.

The bridge can travel in longitudinal direction 600 ft. Coal can be unloaded with this bridge from barges to the storage pile and then rehandled into the shed, or it can be handled by the bridge from barges into the shed, or it can be dropped directly into the hopper feeding the coal crushers and belts to the retort house.

At the north end of the storage ground is an open

FIG. 1. COAL BRIDGE AND COAL STORAGE HOUSE

bin of 1000 tons capacity, which is now being used for buckwheat boiler fuel. Adjacent to this is a space reserved for 10,000 tons of broken anthracite for water gas generation. The rest of the storage space is divided up between high volatile and low volatile coking coals with storage capacity of a total of about 60,000 tons.

Coal Shed—The coal storage shed was arranged to store a maximum of 8000 tons of coal under cover.

The framework of the shed is constructed of "A" steel frame bents, the bents being designed to carry the sides, roofing and tracks of the main trolley, which is used for reclaiming the coal from the storage shed and passing same into the hopper over the crusher.

The bottom of the coal shed and foundations of the steel frame are of concrete. The roof over the shed is provided with movable sections or hatchways, so that the storage bridge may deposit coal into any portion of the shed. This storage shed was originally used for gas coal for the retort house but is now used for storing bituminous coal for use in the producer gas plant. The reclaiming is done by means of Dodge telphers, having 2-cu.yd. buckets.

Retort House

The retort house, which was built entirely by the Didier-March Co., is of German design. The building is 85 ft. wide, 215 ft. long and 59 ft. high to the ridge. The roof is open in the center to give the greatest possible ventilation, combined with louvres placed in the side walls of the house. There were also provided 28 double sliding doors to make the house easily accessible from all sides and 74 windows. A platform was constructed in front of each stack at the height of the bottom of the retorts and another platform in front of the hydraulic mains, with an operating floor around the tops of the benches. The roof was constructed of graduated reinforced asbestos sheets fastened to channel purlins with aluminum wires.

Coal Handling—A steel hopper receives the coal from the telpher or bridge, dropping it into a weighing hopper and thence the coal goes onto an apron feeder, which carries the coal to jaw crushers. From the jaw crushers, bucket elevators carry the coal to the top of the retort house. These bucket elevators have 66-ft. centers and are made up of No. 10 steel "V" shaped buckets measuring 20 in. by 50 in., driven by motors. The bucket elevators discharge onto belt conveyors having 200-ft. centers, which deliver the coal from the elevator to the coal bins. This belt is 18 inches wide

FIG. 2. TOP OF BENCHES

and is provided with a self-propelling automatic reversing tripper running on rails, which discharges the coal automatically over the entire length of the coal bin. Each of these coal bins has a capacity of 260 net tons and is constructed of steel plates properly stiffened. Each bin is provided with a series of discharging valves of the swinging undercut type. At the present time, as the retort house has been abandoned for generating coal gas, the north bin is not in use. The south bin is now used for the fuel for the producer gas plant, which furnishes the gas for heating the coke ovens.

Benches—Four stacks of vertical benches were erected, three consisting of six benches of ten retorts each, the fourth consisting of six benches of fifteen retorts each. In the benches of 10's, the retorts measure 22½ in. by 9 in. at the top and 27 in. by 14 in. at the bottom and are 13 ft. 2 in. long. The recuperating system is located on both sides of the generators, consisting of a system of primary and secondary air flues and adjacent to a series of waste heat flues which convey the products of combustion to the lower portion of the benches. (Fig. 2.)

The generators were located on one side of the benches adjacent to the retorts and the producer gas entered the main oxide flue through two openings about 3 ft. above the grate bars. The coke charging openings are located some 14 ft. above this point on a level with the retort operating floor, this space serving for coke storage.

VAPORIZERS

A vaporizer for each generator was located underneath the ash pan and vaporization was effected by the products of combustion before entering the main smoke flue. The vapors produced were conducted under the grate and thoroughly mixed with the heated primary air. A separate main smoke flue 3 ft. square was provided for each stack connected to a chimney outside the building. Four chimneys were erected of hollow radial molded blocks of the Custodis system and are 125 ft. high with 4 ft. inside diameter at the top.

The lower mouthpieces were operated from the outside of the benches by means of a system of levels, racks and pinions. A separate hydraulic main was provided for each bench. These hydraulic mains were sealed only during charging of the retort, which was accomplished by means of a weir valve, which was raised shortly before charging time and which allowed the circulating liquor to fill up and seal the dip pipes. Underneath each dip pipe was placed a pitch pan, which could easily be removed for cleaning. Two foul mains, one on each side of the house, carried gas to the end of the building and thence to the underground foul main.

CHARGING THE GENERATORS

For charging the generators with coke, a steel plate hopper was used, running on a monorail. Before charging coal into the retort, the bottom of the retort was filled with a small amount of coke breeze by means of a traveling breeze hopper. This was followed by the coal-charging hopper, which was constructed to charge two retorts simultaneously on the benches having ten retorts and three retorts on the benches having fifteen. The coke which discharged from the retorts fell into a movable chute, which brought the coal over to a De-Brower hot coke conveyor located in front of the stacks. (Fig. 3.) Originally the conveyor discharged into a skip hoist, which elevated the coke into a night storage bin, but this system was found unsatisfactory and was changed to deliver the coke into a second conveyor, which, in turn, carried the coke to concrete pits. Just outside of the retort house was a set of water sprinklers, which quenched the hot coke, the steam being carried away by a vertical flue.

The fourth stack of benches to be erected was built with fifteen retorts to the bench, which was thought to give some economies in operation. The retorts were 19⅝ in. by 9¾ in. at the top and 24⅜ in. by 14⅛ in. at the bottom, having the same length of 13 ft. 2 in. The other constructional details were similar with the exception of the method of handling the lower mouthpieces, which were handled by hydraulic valves rather than by hand, which was an immense improvement. Also the steam vaporizers were omitted and step grates were used instead of bar grates. Step grates were also used on the third stack to be built.

The coke which was quenched by the water sprays and carried by a second chain conveyor passed over a grizzly, where a large part of the breeze dropped out, and then fell into concrete pits, whence it was handled by telphers.

A telpher system with a clearance of 54 ft. above ground level handled the coke from the pits to storage or to the screen houses. These telphers were later extended to handle coke to the water gas plant and also

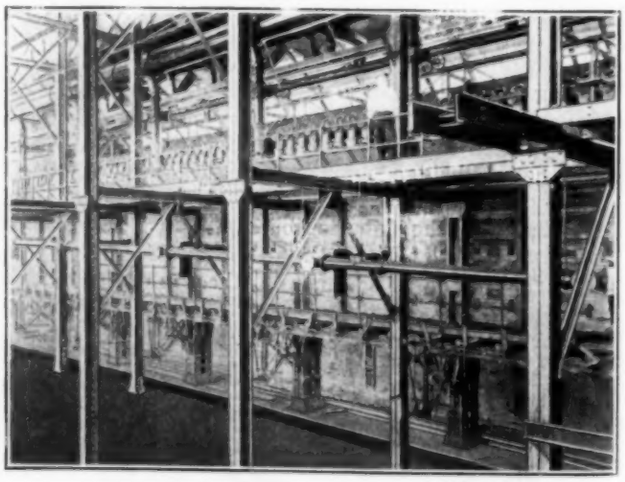


FIG. 3. SIDE VIEW OF BENCHES

anthracite for the water gas plant and coke breeze or other fuel for the boiler plant and, at the time of completing the coke oven plant, they were still further extended to take care of the coke from the ovens.

The coke was handled to storage and to the shaker screen houses with 2½-ton clamshell buckets.

Condensing Plant

Buildings—At the time this plant was built, it was common practice to house all condensing plants. In the past few years, the use of outdoor condensing plants has grown rapidly in favor. The condenser house is 45 ft. wide by 120 ft. long and about 30 ft. high, with brick walls carrying steel roof trusses. The roof is of terra cotta hook tile covered with slate with a monitor extending the whole length of the building, having pivoted sash. Concrete floors are provided throughout.

Condensing Equipment—The condensing plant as originally constructed consisted of two primary condensers, two exhausters, two tar extractors, two secondary condensers, two rotary ammonia scrubbers. Later a Feld washer was constructed to assist in ammonia recovery.

The primary condensers are rectangular water tube condensers, having 3200 cu.ft. effective cooling surface each. The combined capacity of these two condensers is 3,000,000 cu.ft. per day. Following the primary condensers is a duplicate installation of Connersville exhausters, having a capacity of 17 cu.ft. per revolution, and equipped with Isbel-Porter governors. Tar extraction is provided for by two Bartlett-Hayward P. & A. tar extractors with a single submersion chamber, the shell being of cast iron. There are two of these tar extractors and each of them has a capacity of 3,000,000 cu.ft. per day.

Following the tar extractors are two secondary rectangular water tube condensers, each having an effective surface of 6000 sq.ft. (Fig. 4.) The water used on the secondary condensers passes to the primary condensers. The temperature of condensation is controlled by Tagliabue regulators.

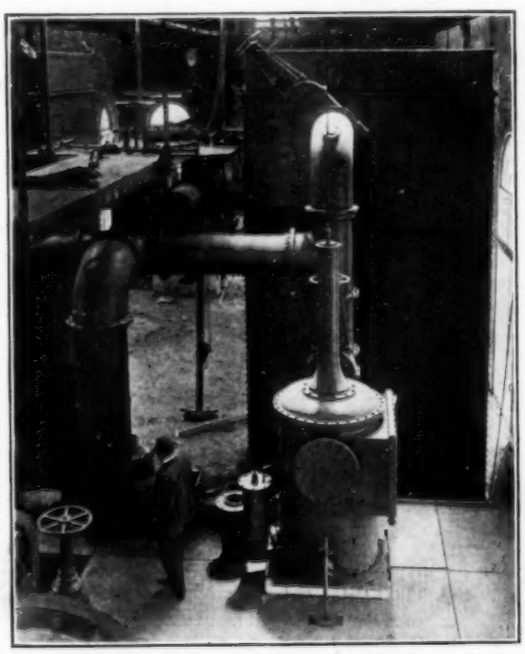


FIG. 4. SECONDARY CONDENSERS

FIG. 5. ROTARY SCRUBBERS FOR FINAL REMOVAL OF AMMONIA

A 5-ft., 7-section Feld washer serves as a primary ammonia scrubber and has developed into a very useful apparatus, for the removal of hydrogen sulphide, in combination with ammonia in the liquor from the secondary scrubbers.

Final Removal of Ammonia

The final removal of ammonia was secured by two rotary scrubbers (Fig. 5) constructed in five days, having a diameter of 10 ft. The washing surface is composed of standard wood grids, the washer being supplied with a small engine directly connected to a worm operating on the worm wheel attached to the shaft. All connections in the building are 24 in. diameter straight pipe made of steel plates, all fittings being made of cast iron.

The tar and liquor from the retort house run into an underground concrete system 20 ft. by 45 ft. by 10 ft. in depth, where the tar and liquor condensed in the retort house are separated. The weak liquor collected at this point was used for sealing the hydraulic mains and finally found its way to the main ammonia liquor storage. The tar collected in the separator was pumped to an overground steel tank located near the retort house.

Alongside the condenser house there is an underground concrete ammonia tank measuring 35 ft. by 120 ft. by 10 ft. in depth, wherein is received and stored all the tar and liquor collected from the condensing and purifying plants. The tar separated at this point was sent to the overground tar tank and the ammonia delivered to the ammonia works.

Purifying Plant

Buildings—The purifier house is 110 ft. long by 61 ft. wide and 36 ft. high and accommodates four purifiers. The building is of steel frame, the space between the frames and around the outside of the columns being built of brick. The roof is covered with hook tile carrying slate. A stairway leads from the ground floor to the operating floor around the boxes. This operating floor is built of steel plate. The roof is provided with a monitor extending the whole length of the building carrying a monitor sash. The general design of the building is similar to that of the other plant buildings, having granite trim and general handsome appearance. The purifying boxes measure 40 ft. by 20 ft. by 10 ft. deep and contain three layers of oxide with valve con-

nections to provide a triplex flow of gas. (Fig. 6.) The covers of the boxes are supplied with rubber lutes and holding down clamps and are handled with an overhead traveling crane. The system of valves and fittings is arranged so as to work the boxes either in forward or backward rotation.

In dumping a box, the oxide is dropped through openings in the bottom of the box onto a concrete floor. In filling a box, the wheelbarrows of oxide are raised to the operating floor by a Craig Ridgway steam hydraulic elevator.

Meter House

From the purifying plant, the gas passes underground in a 24-in. main to the meter house, which is 40 ft. by 45 ft. by 20 ft., constructed of brick with steel roof trusses, the roof being of hook tile carrying slate. Space is provided in this building for four meters. When the coal gas plant was built, one 14-ft. meter was installed by the Nathaniel Tufts Meter Co., and supplied with a Hinman drum. A photometer room was also constructed in the space provided for one of the future meters.

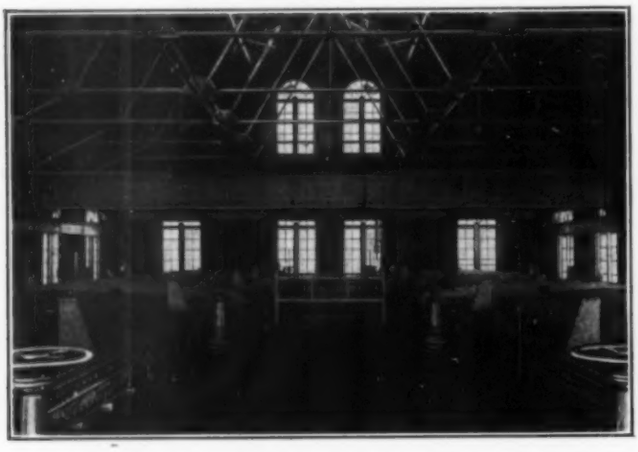


FIG. 6. COAL GAS PURIFIER BOXES

Power Plant

The power plant is housed in two buildings; one containing the boilers and the other containing the engines, generators and auxiliary machinery. The boiler house is 88 ft. by 65 ft. by 30 ft. high, of the same general construction as the other buildings on the plant. When first built three B. & W. 440-hp. boilers were installed, equipped for hand firing. A radial brick chimney was provided and additional forced draft was secured by means of an engine driven Sturtevant fan. An open-feed water heater was provided for the boiler water, but for the first few years very little exhaust steam was secured and the temperature of the water entering the boilers was never very high.

Engine House—The engine house is 46 ft. by 90 ft. and contains a main operating floor and basement. On the main operating floor are two 300-kw. cross compound, direct connected Allis Chalmers engines and generators. (Fig. 7.) These engines run condensing, utilizing salt water from the bay to operate barometric condensers. A 250-volt d.c. electric current is generated and is distributed through a switchboard to various circuits in the plant. Electric power is utilized for all possible operation of machinery.

In the cellar of the engine house are located the centrifugal boiler pumps, the condensing pumps and the fire pump, which utilizes salt water from the bay.

Water Tower and Wells—There are three sources of water supply for the works. Water from the city mains is used for boilers and other purposes where pure, fresh water is required. A set of driven wells was put down to a depth of about 50 ft., tapping underground veins of water, which some time after their construction unfortunately became contaminated with salt water from the bay. These wells are provided with two Davidson electric pumps, delivering the water into a tank on a tower, the tank having a capacity of 100,000 gal. of water and being elevated about 80 ft. from the ground.

Results in Operation

The coke made in this plant was of a very superior quality and found a ready sale for all domestic purposes. The yield of gas, tar and ammonia was satisfactory. When the plant was first started, it was very economical as to labor, but conditions later developed which caused the labor account to be high.

FIG. 7. ENGINE ROOM

This was the pioneer plant in America of Dessau vertical retorts, which accounts for many of the operating difficulties encountered. There are now several very successful installations of vertical retorts on the Dessau system wherein American conditions have been more thoroughly taken into account.

Water Gas Plant

During the year 1915, it became evident that the capacity of the South Station for generating water gas would soon be exceeded by the demand, and it was decided to build a complete new water gas plant at the Sassafras Point Station. In July, 1915, the Bartlett Hayward Co. of Baltimore presented plans and specifications for this plant, which were accepted, and construction was commenced, gas being made in the new plant about the first of December, 1916. Mr. R. E. Slade had succeeded Mr. Carroll Miller as engineer for the gas company, and it was under his direction and supervision that the water gas plant was planned and constructed. The manufacture of water gas at the Sassafras Point Station involved the erection of a number of buildings, including a generator house, engine house, washer house, purifier house and a set of coal and coke bins. It also involved the erection of a relief holder, two oil tanks, extension of the boiler capacity, extension

of telpher lines, the moving of two station meters from the South Station to the new plant and also a 500,000-gal. tar tank. (Fig. 8.)

With the exception of the water gas machines, which were furnished and installed by the United Gas Improvement Co., all of the construction was undertaken by the Bartlett Hayward Co., although apparatus from several other firms was specified for certain purposes.

Coal and Coke Handling

Adjoining the generator house and located between the generator house and the boiler house, a set of coal, coke and breeze bins was erected. These bins were about 120 ft. long and 23 ft. wide and were constructed of steel plates stiffened with steel beams supported on "H" columns roofed over with asbestos-protected metal. A steel partition runs lengthwise through the bunkers, so that boiler fuel may be separated from water gas fuel. In addition to this, wooden partitions were later put in, so that water gas coal and water gas coke could be separated and also different varieties of boiler fuel could be kept separate.

There are steel chutes with undercut gates serving the boiler house and the operating floor of the water gas plant.

Anthracite which is stored on the waterfront is delivered into the north end of the coal storage shed by the coal bridge. The telpher lines were extended to serve this coal store and coal is brought by telphers to a new hopper, which also takes coke, breeze and boiler coal handled by telphers from their respective storage piles. This hopper delivers to a motor driven 30-in. belt, having 205-ft. centers, with a capacity of forty tons per hr., which conveys the fuel up an incline to the proper elevation, then horizontally above the bins to the end of the bin house. A traveling unloader runs on rails above the bins and discharges the fuel where desired.

Buildings

The generator house is of steel frame construction, the roof being carried on steel purlins and trusses, the trusses spanning the entire width and being supported on steel columns securely anchored to the building foundations, so that all loads are carried independent of brick side walls. A steel frame monitor, carrying swinging windows, is constructed on the roof. The end walls are carried up above the ends of the roof and are capped with stone. This building is 217 ft. long, 71 ft. wide and 31 ft. 10 in. high from the ground floor to the bottom chord of roof trusses. This building was so laid out as to accommodate five sets of water gas generating apparatus, but to date three sets only have been installed.

The exhauster and pump house is 60 ft. long by 41 ft. wide and is of the same general construction as the generator house. The operating floor for the engines and exhausters is slightly above grade, and a pump room is provided somwhat below grade. Space was provided for three exhausters, only two being installed at present.

The tar extractor and washer house is 41 ft. long, 37 ft. wide and 21 ft. high. It has 13-in. brick walls with stone trim, the roof being carried on steel trusses anchored to 17-in. pilasters. There is a monitor on the roof with pivoted sash.

The purifier house is of steel frame construction with brick filled sides and gable roof, the roof being carried

FIG. 8. GENERAL VIEW SHOWING ORIGINAL COAL GAS PLANT AND WATER GAS PLANT ADDED IN 1915

by steel purlins and supported by trusses carried on steel columns. An outside steel stairway runs to the purifier floor. There is an additional stairway inside the building. The dimensions are 112 ft. by 61 ft. inside and 44 ft. 6 in. high from the ground floor to underside of roof trusses.

The roofs of all building are of terra cotta hook tile laid in cement with slate covering. All buildings are substantially built and have a handsome appearance.

Editor's Notes: This article is to be continued. Part II will describe in detail the new water-gas plant and Part III the Koppers combination-gas ovens.

Industrial Alcohol Act

At the present time industrial alcohol manufacturers are subjected to practically all the restrictions that are imposed upon the distiller of whiskey, with the result that production costs are unreasonably high.

To meet this situation, the Internal Revenue Bureau has drafted a bill, H. R. 5029, which is designed to make it possible for the Secretary of the Treasury and the Commissioner of Internal Revenue to relieve distillers of industrial alcohol from unnecessary and costly supervision in order that industrial alcohol may be made at minimum cost.[1]

This bill provides for the registration, bonding and licensing of plants and warehouses for the manufacture, storage and distribution of alcohol which is to be used exclusively for non-beverage purposes. Those plants which are producing industrial alcohol exclusively at the present will be required to apply for registration within thirty days after the passage of the act. Legally established distilleries or bonded warehouses may also apply for permits to operate as industrial alcohol plants and warehouses. The alcohol may be produced from any raw materials and by any suitable process.

Such alcohol is subject to taxation but, by filing application and bond and obtaining a permit, a denaturing plant may be established at any industrial alcohol plant, and the denatured product sold free of tax for domestic or foreign use. Undenatured alcohol may be withdrawn, tax free, for the use of any university, research laboratory, or any hospital not conducted for profit.

The industry is to be regulated by the Commissioner of Internal Revenue (with the approval of the Secretary of the Treasury) in such manner that an ample supply, produced under the most efficient conditions, shall be available for scientific research and the development of fuels, dyes and other products.

[1]Testimony of Deputy Commissioner Gaylord of Internal Revenue Board at hearing before the House Judiciary Committee.

Jubilee Meeting of the Iron and Steel Institute

THE Iron and Steel Institute (British) held its fiftieth annual meeting in London on May 8, 1919. The secretary reported the total membership of 2098. During the preceding year four new applications were received for grants of £100 each from Andrew Carnegie Research Fund, as follows: S. L. Hoyt, Minneapolis, for an investigation on the foreign inclusions in steel; J. N. Kilby, Sheffield, for an investigation on the basic open-hearth process, including its chemistry; G. Patchin, London, for research upon semi-steel and its heat treatment; J. A. Van den Broeck, Ann Arbor, for a continuation of studies on the effect of cold-working on the elastic properties of steel.

The Bessemer medal was presented to M. Leon Greiner.

The technical program contained a large number of excellent papers of which we present the following synopsis.

Nature of Transformations in Iron

A review of the evidence regarding the nature of the various transformations in iron was presented by Prof. K. Honda of the Imperial University, Sendai, Japan, "On the Non-Allotropic Nature of the A_3 Transformation in Iron." Regarding the change in physical properties with change in temperature as being due to variations in amplitude of atomic vibrations, an allotropic change occurs when these thermal vibrations exceed the limits of equilibrium of the then existant structure, and a new atomic configuration results. Since all changes take time, real allotropic transformations may spread over a considerable temperature range, and are difficult to distinguish from non-allotropic variations of physical properties as to temperature. However, the criterion of the latter is that the property of a substance bears a fixed relation to the temperature, unchanging with time, whereas allotropy is a transformation which proceeds at a definite temperature, if a sufficient time be allowed.

For pure iron there have been shown to be two real transformations, A_3, occurring at 893-898 deg. C. (3 hours' time being required) and A_4 occurring at 1385-1390 deg. (but a few minutes being required). A_2—the magnetic transformation—on the other hand, begins at ordinary temperatures, its rate of change increases with temperature until at 785 deg. C. the test piece changes from the ferromagnetic to the paramagnetic state. An explanation of such changes is given, based upon the molecular theory of magnetism; wherein the author concludes that the A_2 transformation is not truly allotropic, but is the process of requiring the rotational energy of molecules, whose amount is a definite function of temperature.

In the case of carbon steels, there are two other transformations. A_1, at 700-750 deg. C. is the eutectic transformation of cementite and ferrite, proved to take place at definite temperatures if the rate of heating or cooling is sufficiently slow, and therefore an allotropic change of phase. A_0 at 215 deg. C. is the critical point of cementite and is of exactly the same variety as A_2—that is, non-allotropic.

A. Cesáro, of Liège University, presented a "Note on the Liquidus in the Iron-Carbon Diagram." On the assumption that the liquidus should be a straight line, the author shows mathematically that absolute rectilinearity cannot be obtained when using numerical values obtained by Carpenter and Keeling on any supposition as to the number of atoms of iron in a liquid molecule. He also shows that the nearest approach to plus or minus 8 deg., or within the experimental error, is when the iron molecule is regarded as Fe_3 and the melt assumed to consist of $Fe_3C \cdot Fe_3$ rather than of $F \cdot C$. Raoult's law, which leads to a straight line, presupposes dilute solutions of alloys not forming solid solutions upon solidification, neither condition being satisfied in the iron-carbon diagram. The author then applied the more general law to the Le Chatelier-Schroeder.

$$\ln z = \frac{Q}{2}\left(\frac{1}{T_0} - \frac{1}{T}\right)$$

where temperatures are expressed above absolute zero, and z is atomic per cent of solvent (gamma iron). Computing theoretical values of melting points T and comparing them with values observed by Carpenter and Keeling shows a much wider divergence than those found by Raoult's law, but as before a better agreement on the assumption that the melt consists of molecules of Fe_3C and Fe_3.

Macro-Etching and Macro-Printing

It is often very desirable to develop and print the macro structure of large steel sections for purposes of study and comparison. J. C. W. Humfrey, of the Inspection Service, describes a novel method of doing this in his paper "Macro-etching and Macro-printing." Sulphur printing on silk or silver bromide paper reveals the major segregates excellently, but the minor segregation—that occurring within the boundaries of the original crystal—is not revealed unless sulphur is very high. Besides, very great care is necessary to avoid movement during printing and insure uniform contact. Strong (10-20 per cent) solutions of hot HCl or H_2SO_4 act upon sulphide inclusions in much the same way, and require high sulphur metal for good results. Heyn's reagent (12 per cent Cu $(NH_3)_2$ SO_4) is hardly sufficient to reveal minor segregations of phosphorus. Solutions of nitric acid are particularly useful for revealing fine flaws, which show after deep etching by a slight oozing when the surface is wiped clean and carefully dried with alcohol. It is very delicate in revealing locally decarburized areas, especially while the acid is still attacking. Acid cupric reagents are remarkably sensitive, but the surface should first be given a fine polish. At best any of these later methods must be photographed for record, which, in the case of large sections, will involve a reduction in scale.

Humfrey finds that a reagant such as

$Cu(NH_3)_2SO_4$	120 g.
Conc. HCl	50 cc. (more or less)
H_2O	1000 cc.

is as delicate as any previously recommended, and can be used for very deep etching of a machined surface, after which it can be printed like a type-form on a proof press or in a letter-copying press. Etching is best done on the surface supported horizontally, starting with Heyn's solution, etching deeply to eliminate tool marks and surface hardening and then continuing with the new acid solution by pouring on fresh additions at intervals. Deposited copper can readily be wiped off; in case examination reveals insufficient attack, it should be resumed first with the neutral reagent. The strong relief is brought out by light buffing. To print, merely ink

with a proof roller, place on the bed of a copy press, cover with "glossy art paper," overlay with two thicknesses of broadcloth, and apply pressure.

This solution acts by attacking the purer portions which solidified first with greater vigor, leaving in relief the major and minor segregates, which thus print black on the proof. Some very beautiful examples of work on shell forgings are illustrated in the original paper.

Graphitization in Iron-Carbon Alloys

Whether graphite or cementite is the stable constituent of pure iron-carbon alloys was again discussed by K. Tawara and G. Asohara of Tokyo University. They cast a number of triangular ingots, in preheated clay molds, and studied the effect of six variables with regard to graphitization. First, chemical composition (that is to say, carbon content, the amount of silicon being held at 0.05 per cent or less, while the other impurities were very low) appeared not to be a decisive factor in graphitization. Graphite was always seen in a slowly cooled ingot containing from 2½ to 3½ per cent carbon, although in relatively larger amounts in higher carbon irons, which would be expected if the constituents appearing at primary solidification were austenite and graphite only. Second, the maximum temperature attained by the molten iron appeared to have no effect. Thus no excess decomposition of Fe_3C by superheating appeared to persist at the liquidus. Third, temperatures of casting up to 1400 deg. C. for a 3.3 per cent C appeared to cause no differences. Fourth, temperature of the mold had a large effect due to the speed at which it cooled the metal through the solidification range. Thus no graphite was found after pouring in a mold heated to 900 deg. C., held for 7 hr. at that temperature and then quenched. When cast in a mold heated to 1000 deg. C., held for 8 hr. and then quenched, graphite appeared in spots only. When cast in a mold heated to 1100 deg. C., held for 1½ hr. and then quenched there was plenty of graphite. However, the same procedure in a mold at 1125-1128 deg. C. gave no graphite. The authors interpret the last results as meaning that the metal (3.3 per cent C) was held liquid in the mold, and when quenched it was white iron; a mold at 1100 deg. C. giving an optimum cooling rate through the mushy stage for graphitization. Fifth, when the mold is 1100 deg. C. and the subsequent cooling is slow, the metal is completely graphitized independently of the time it is held at 1100 deg. C. Sixth, with a mold at 1100 deg. C., the speed of subsequent cooling merely affects the method of deposition of the primary austenite, water quenching producing martensitic ground mass, and slow cooling producing pearlite and needle cementite.

From these experiments the authors conclude that homogeneous graphitization takes place during the slow cooling of the metal down to 1100 deg. C., covering a time longer than 30 min., and when uninfluenced by such accelerators as silicon and manganese, does not occur at 1000 deg. C. even after 8 hours' uniform heating. Consequently they believe that cementite in the melt is at least partially dissociated, and if time be given during solidification, the free carbon thus in existence will crystallize as graphite particles causing more cementite to decompose, enriching the melt in ferrite, the contemporaneous product of dissociation, when finally the remaining melt will have the composition of saturated austenite. Thus is the stable alloy produced. On more rapid cooling, decomposition of molten cementite is incomplete, whence the metastable "mottled" iron. The authors consider a graphite crystal as being an element of the eutectic; the lamellar structure ordinarily expected of a eutectic is thus absent due to the slow cooling of the melt. Such crystals are surrounded by resolved austenite (needle cementite plus pearlite), as they should be, and not by ferrite resulting from a hypothetical decomposition of Fe_3C.

Influence of Rate of Cooling on Hardening Carbon Steel

"An Experimental Investigation of the Influence of the Rate of Cooling on the Hardening of Carbon Steels" was described at considerable length by the prominent French metallurgist, A. M. Portevin of the Ecole Centrale des Arts et Manufactures, Paris, and his associate, M. Garvin. In a preliminary part the authors describe in detail their apparatus and method of tracing cooling curves at very rapid rates. A platinum couple whose elements were but 0.1 mm. in diameter was used in order that its heat capacity be negligible, and actual contact at the center of the cylindrical test piece was periodically verified by measuring the resistance, couple to specimen. In order that this contact might not be disturbed, the specimen and couple were both held stationary by a nickel-steel tube fixed to the upper head of a standard. Heating was done by a Meker blast lamp; when a predetermined temperature was reached the lamp was rapidly lowered, a quenching cup swung into place, and the specimen was cooled by a uniform flow of water. Automatic records were made photographically by a beam of light from a galvanometer mirror; the paper contains information as to necessary precautions and corrections to insure proper time and temperature registration.

Their problem was to determine for a given steel how the transformations, structure and hardness vary with different rates of quenching (τ from 700 to 200 deg. C. was the unit of comparison) and the initial temperature of quenching. Different speeds of quenching were had by using geometrically similar specimens of varying diameter; after quenching the pieces were broken across their center and the microscopy and Brinell hardness of the spot directly in contact with the thermocouple junction examined. A series of such curves for 1.07 C steel is illustrated in Fig. 1, and it is seen that rapid cooling suppresses transformations until 300 to 350 deg. C. Such cylinders are entirely martensitic and their hardness is uniformly close to 600. On cylinders 14 mm. in diameter and larger, however, this lower transformation Ar″ is suppressed and an upper one, Ar′, at

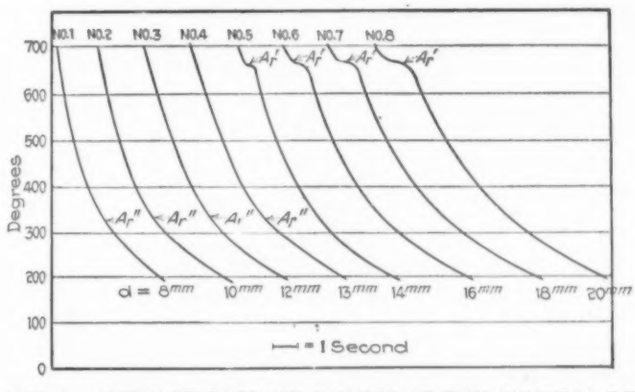


FIG. 1. AVERAGE COOLING CURVES AT THE CENTERS OF GEOMETRICALLY SIMILAR CYLINDERS OF STEEL CONTAINING 1.07 PER CENT CARBON AND 0.08 PER CENT MANGANESE, QUENCHED IN WATER

635 to 665 (depending upon the speed) appears. Such cylinders show uniformly a troostitic core, of hardness, 400, surrounded by a shell of martensite of thickness decreasing as the diameter increases. There is therefore a critical range in the rate of cooling (in this particular steel, about 7 sec. from 700 to 200 deg. C.) at which the interval transformations suddenly change their nature and position on the temperature scale. When quenching at speeds near this rate, the same steel will sometimes appear troostitic, sometimes martensitic, and sometimes both Ar′ and Ar″ are in evidence, giving a martensite-troostite complex.

Experiments by the authors demonstrate that composition has much to do with the critical rate. Particularly manganese will increase the critical time between 700 and 200, imparting quasi self-hardening properties. Variations in carbon also appear to have a marked influence. Eutectoid steels have slow critical rate as compared with either hypo-eutectoid or hyper-eutectoid, either of which tends to become troostitic with the separation of the pro-eutectoid constituents, ferrite or cementite respectively. This excess constituent may well be the cause of the phenomena, presenting nuclei unabsorbed into the austenite around which crystallization proceeds, correspondingly inducing formation of troostite. Unabsorbed nuclei may be the reason why previous heat treatment, mechanical working, method of manufacture, duration of heat and temperature of quenching all have an effect upon the speed of quenching.

In particular, raising the quenching temperature in the neighborhood of the critical rate tends to make Ar′ disappear, as does also a second quenching. Also the authors point out that various facts already determined about quenching hold true at rates somewhat distant from the critical—thus τ varies as diameter of geometrically similar cylinders except at the critical rate, nor does hardness vary as the temperature of quenching (except at the critical rate), and with the same provision, the agitation, rate of circulation, or temperature of cooling water will not affect the hardness of drastic quenchings. By interrupting the quenching at various temperatures, the authors were also able to form troostite (γ iron-carbon solution $\longrightarrow$ Fe_3C + α iron complex) at temperatures as slow as 400 deg. Strong recalescence is exhibited in such curves, and microscopically the troostite is strongly marked and bulky, both the characteristics of a sharply defined reaction, much different from that which occurs when annealing martensite to troostite, osmondite or sorbite.

Two Papers on Tool Steel

"The Manufacture and Working of High-Speed Steel" was described in a paper by J. H. Andrew and G. W. Green of the Metallurgical Research Dept., Armstrong, Whitworth & Co., wherein they gave the practice at the Openshaw works in manufacture of steel bars with 14 per cent W, 3.8 per cent Cr, 0.5 per cent V, and 0.6 per cent C. Such material is melted in crucibles, and poured at 1420 ± 20 deg. C. into ladles, wherefrom it teemed at 1335 ± 5 deg. C. into chills, making a top-cast ingot 6 in. square and weighing 350 lb. After 30 min. the ingots are stripped, being then at 650 deg. and annealed in a gas-fired furnace for 48 hr. at 800 deg. C. Microsections now show excessive carbide segregation at the skin, and fine structure at the outer portion of the ingot. In the center is coarse-grained structure with thick walls of carbide.

Drillings from various parts of the ingots and croppings show practically no measurable segregation. This, as well as the entire absence of blowholes, is probably due to the small size of ingot, and the very quick solidification, due to the chill-mold and high alloy content.

Mechanical and heat treatment are resorted to in order to reduce this crystalline structure to an extremely fine grain, it having been found that 88 per cent reduction is necessary before the distorted carbide envelopes lose their dangerous form of loops and hooks. Whether reduction is done by rolling or forging is immaterial, as long as the working temperatures are correct, which, by the way, are greater than generally thought to be correct.

A good practice is cited as folows: After annealing, the ingots are preheated, attaining 820 deg. C. in 24 hr., then transferred to another furnace and brought to 1170 deg. in 4 or 5 hr. Cogging from 6 to 3½ in. square was done under a 1½-ton hammer, occupying about 4½ min., at which time the temperature was 1000 deg. C. Ten per cent of the head was cropped off; and any surface cracks gouged out with a steel tool, as is done after each reduction. Microsections now show well disseminated carbide in the outer portions, but at the center the envelopes are merely distorted.

After the 3½-in. billets are cut in half, they are aired under the fire-bars and finally charged into a cool-fired furnace, attaining a temperature of 1150 ± 20 deg. C. and soaking until the forge is ready for them. Forging one end to 1⅝ in. requires slightly less than 2 min., during which time the temperature falls 50 deg. The large end is reheated and drawn under the same conditions. Microscopically, the carbide now is in laminated, band-like zones, occasionally appearing as semi-decomposed austenite.

From 1⅝ in. the bars are tilted or rolled to 1¼ in., rolling starting at 1030 deg. C. and requiring 15 to 18 passes, consuming nearly 2 min., the temperature dropping about 10½ deg. per pass. Tilting is done on each end separately as before, requiring about 2 min., during which the temperature drops from 1100 deg. to 850 ± 50 deg. At this point the carbide envelopes are broken up into grains, but these still assume laminated arrangement as to position.

In older practice the 1¼-in. bars were then annealed by heating to 800 deg. C. in 24 hr., then damp the furnace from 3 to 6 hr., when the bars were furnace cooled during 36 hr. This required 3 days, and the structure was not refined (800 deg. being lower than the transformation range). Newer practice heats slowly to 900 deg. C., soaking a little time, cooling in furnace to 700 deg. C., and cooling in air. Cast structure is now eliminated, the bars have been softened from Brinell 616 to 250, and are ready for shaping into machine tools.

Lathe tools are hardened by gradually heating to a medium red heat, then quickly heating the nose to 1290-1300 deg. C., when it is quickly withdrawn and cooled in air-blast or oil attaining Brinell 650. Quick heating, consistent with adequate soaking, is desirable, since high and prolonged temperatures promote grain growth, without materially affecting any improper carbide distribution persisting to this point. A difference of 5 deg. in the maximum will increase the grain size 15 diameters (Figs. 2 and 3), while 10 deg. to 1310 will liquefy the carbide eutectics. At 1350 deg. the specimen is completely "crozzled." (Fig. 4.) Tool failures may be due to persistent dendritic structure inherited

from too hot casting, rare segregations of slag or manganese sulphide, forging cracks, but most often carbide segregations forming banded laminations or grain envelopes.

A study of the microscopic and mechanical properties of several tool steels was presented by Dean J. O. Arnold, and Fred Ibbotson, of the University of Sheffield. Previous researches on plain carbon steels with the addition of a single alloying element has already distinguished the various carbides of chromium, vanadium, tungsten and molybdenum. In the complex mixtures used in these experiments, the same methods were used, namely, electrolysis of the tool steel in HCl (sq.gr. 1.02). The residue of carbides was then analyzed, whence formulæ could be ascribed.

It appears that the relative affinity of carbon for the alloying elements is V, Mo, W, Cr, and lastly Fe. Consequently, with the modest amount of carbon present (0.65 per cent) Fe_3C may be entirely absent in high W-V steels, the hard Cr_3C_2 also giving way to Cr_4C. Microscopically, all the steels in annealed condition are similar, showing a pale background of an intermetallic solution overlaid by dark troostitic and paler sorbitic varieties of a pearlite of unknown composition, the whole being overlaid by nodules (sometimes streaks) of a brilliant white metaral; doubtless a mixture of segregated carbides. When quenched from 1300 deg. C., the Mo-V steel shows well-marked allotriomorphic crystals of a mixed hardenite, which, here and there, are partially surrounded by a unique dark-etching pearlitic constituent, possibly a troostitic vanadium pearlite which does not transform into its hardenite until 1400 deg. A molybdenum steel with no vanadium does not show these areas. Other steels showed allotriomorphic crystals of hardenite of varying sizes, surrounded with thin-cell walls with fairly thick and very broken cell walls of cementite more or less segregated into nodules (sometimes in the crystals themselves).

Chemically the steels were designed to have constant carbon 0.65 per cent, chromium 2.85, silicon 0.4, manganese 0.2, phosphorus 0.015, sulphur 0.06. Vanadium when present was 1.25 per cent, molybdenum either 2 or 6 per cent and tungsten either 12 or 16 per cent. Efficiency tests were made by speeding up a lathe tool until it broke, and measuring the amount of steel removed, with the results shown in the accompanying table.

From the results molybdenum appears to be an acceptable substitute for tungsten at the ratio of about 1 molybdenum to 2.7 tungsten.

Steel No.	Efficiency Position	Type	No. of Tests	Lb. of Steel Removed
1574	1	V-Mo	Six	111.90
1578	2	V-W	Six	109.80
1576	3	V-W-Mo	Six	96.10
1577	4	W-Mo	Six	72.00
1579	5	W	Six	66.60
1575	6	Mo	Five	47.00

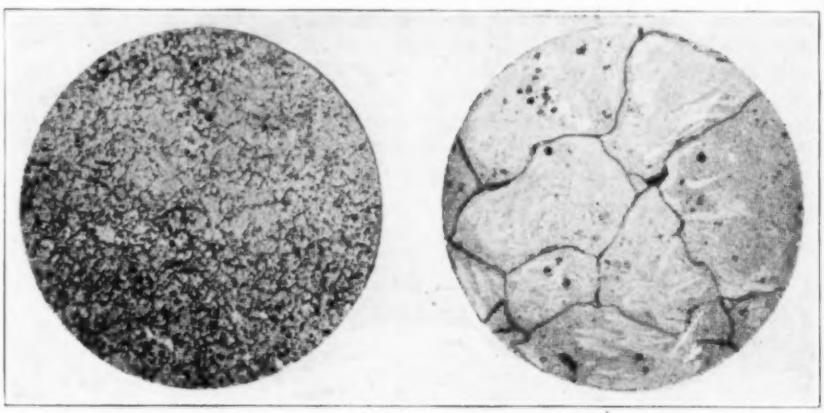


FIG. 2. IDEAL HARDENED CONDITION. TEMPERATURE 1300 DEG. C. X 200, REDUCED ONE-THIRD

FIG. 3. OVERHEATED IN HARDENING. TEMPERATURE 1305 DEG. C. X 200, REDUCED ONE-THIRD

FIG. 4. STEEL HARDENED AT 1350 DEG. C. X 200, REDUCED ONE-THIRD

Study of the Open-Hearth Process

Mr. B. Yaneske, of Vickers, Ltd., Sheffield, described in detail a typical melt which he had found best suited, in "Deoxidation, and the Influences of Lime on Equilibrium in the Acid Open-Hearth Furnaces." The nub of his process was to use extreme heat, and to control the silicon (and therefore oxygen) content of the bath as it approached the desired chemical content, by the careful addition of lime. For instance, he melts very hot to attain a very acid slag, since the acidity in equilibrium increases with temperature. When clear melted and very hot the slag will contain about 48 per cent SiO_2, 33 per cent FeO and 16 per cent MnO, the latter variable as to the nature of the pig melted. At this point ore may be added to maintain basicity, complete the elimination of silicon and to speed the "boil." As the heat progresses the slag gets lighter in color and more viscous, until finally SiO_2 becomes supersaturated and it is reduced by the metallic iron, this state of affairs evidencing itself by blowholes on the under surface of metal samples. Then limestone is added sparingly, with the ore, the former to satisfy the SiO_2 and the latter to continue to lower the carbon content of the bath. This method, by the way, is far better than to liquefy the slag by lowering the flame or by chilling with scrap, either of which increases the FeO in the slag by oxidizing metal. At a continuously high temperature, therefore, the decarbonization proceeds, a proper slag being about SiO_2, 58 per cent; FeO, 21 per cent; CaO, 5 per cent; MnO, 12 per cent, and appearing light green in a quenched sample, the metal being watched for bubbles, meanwhile, and fresh additions of lime made as they appear.

As the carbon content approaches that desired in the finished metal, lime additions are made with caution, and only as indicated by the appearance of blowholes from the reaction

$$SiO_2 + Fe = FeSi + O_2$$

Too much lime displaces FeO from the slag, which in turn lowers unduly the carbon in the melt. After sufficient "stewing," metal spoon-samples will appear perfectly sound, with rippled upper surface due to the high-surface tension of pure metals. It is very hot and may readily be cast, and requires few additions for deoxidizers, with the attendant expense and resulting undesirable solid non-metallic inclusions in the steel. Undue loss of additions and a resulting certainty of final analysis are added advantages.

Contained in the paper are descriptions of the appearance of the metal and slag buttons for other conditions than the optimum, together with a discussion of proper methods to recover equilibrium in the bath

A study of acid open-hearth slags and hearths and their influence on steel-making was presented by J. H. Whitely and A. F. Hallimond of the chemical laboratories, South Durham Steel & Iron Co., in "The Acid Hearth and Slag." Their studies were confined to large slag balls principally of the system $FeO \cdot MnO \cdot SiO_2$, relatively free from lime, and have shown that three minerals, silica, rhodonite and fayolite, are the normal constituents, the first to crystallize being determined by the amount present. When lime is present over 8 per cent, an unknown needle-like metasilicate is present.

The hearth itself, even though made up of pure selected silica, contains large quantities of impurities. Its interstices are rapidly filled by slag, which at operating temperatures is mostly molten, and being in equilibrium with the solid quartz grains, is saturated with silica. This liquid filling is of first importance in preventing cracking during temperature changes. The upper layer of the hearth itself contains up to 8 per cent Fe_2O_3 (as compared to approximately 1 per cent in the slag balls), showing the oxidizing effect of the heated atmosphere when exposed between melts. Fortunately the depression in freezing point of silica (or perhaps its decrease in viscosity) by impurities is exceptionally small, which is responsible for the stability of the banks at temperatures at or above its melting point. Pure silica is not desired for fettling, for a minimum of clay, etc., is necessary to "stick" the grains together, without causing the banks to "soften"; on the other hand, inversion of quartz to tridymite is accelerated by impurities, which transformation is accompanied by flowing and crystal growth, all elements of instability. Patching on the bottom also requires a granular material which will absorb residual metal and slag and knit into the foundation in one continuous mass.

In manipulation of acid melts, slag composition is regulated by the addition of ore, which regulates the purification and also maintains the slag at the proper fluidity without excessive cutting of the banks. Calculations of the amount of oxygen required for elimination of impurities, as compared with that furnished by ore, show that if silicon and manganese are taken into the slag by iron or calcium oxides, at least half of the carbon was eliminated by gas oxidation and the remainder of the carbon by ore addition. Large quantities of ore added to a slag will not appreciably increase its ferric iron content; evidently reduction of Fe_2O_3 to FeO is very rapid. It is known that Fe_2O_3 dissociates under atmospheric pressure at 1350 deg.; furthermore, in the system $SiO_2 \cdot Fe_2O_3 \cdot FeO$ a maximum of 4 per cent Fe_2O_3 is probably the limit at furnace temperatures. As a matter of fact, slags have ordinarily much less—seldom exceeding 0.4 per cent Fe_2O_3—the reduction from 4.0 to

TABLE I.—NORMAL STEELWORKS SLAGS

Process	Acid Bessemer Hematite Nil		Acid Open-hearth Hematite Oxides, lime		Acid Open-hearth Hematite Oxides only		Acid Mixer Any Iron Oxides, lime		Basic Mixer Any Iron Oxides, lime		Basic Open-hearth Hematite Oxides, lime		Basic Open-hearth Common forge Oxides, lime		Basic Open-hearth "Thomas" Oxides, lime		Basic Bessemer "Thomas" Lime	
Pig-iron (See Table II)																		
Additions																		
Normal variations	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
SiO_2	62.0 to 68.0	= 65.0	57.0 to 63.0	= 60.0	48.0 to 52.0	= 50.0	38.0 to 46.0	= 50.0	36.0 to 42.0	= 39.0	25.0 to 29.0	= 27.0	14.0 to 22.0	= 18.0	10.0 to 14.0	= 12.0	6.0 to 10.0	= 8.0
P_2O_5									0.5 to 1.5	= 1.0	0.0 to 2.0	= 1.0	7.0 to 13.0	= 10.0	14.0 to 18.0	= 16.0	18.0 to 22.0	= 20.0
Al_2O_3									0.5 to 1.5	= 1.0	1.0 to 3.0	= 2.0	1.0 to 3.0	= 2.0	1.0 to 3.0	= 2.0		
CaO	4.0 to 6.0	= 5.0	12.0 to 18.0	= 15.0	5.0 to 9.0	= 7.0	9.0 to 15.0	= 12.0	40.0 to 48.0	= 44.0	46.0 to 50.0	= 48.0	46.0 to 50.0	= 48.0	46.0 to 50.0	= 48.0	48.0 to 52.0	= 50.0
MgO									5.0 to 7.0	= 6.0	4.0 to 6.0	= 5.0	4.0 to 6.0	= 5.0	4.0 to 6.0	= 5.0	4.0 to 6.0	= 5.0
MnO	8.0 to 12.0	= 10.0	5.0 to 15.0	= 10.0	5.0 to 15.0	= 10.0	4.0 to 8.0	= 6.0	4.0 to 6.0	= 5.0	4.0 to 12.0	= 8.0	4.0 to 12.0	= 8.0	4.0 to 12.0	= 8.0	4.0 to 12.0	= 8.0
FeO	18.0 to 22.0	= 20.0	12.0 to 18.0	= 15.0	28.0 to 38.0	= 33.0	35.0 to 45.0	= 40.0	3.0 to 5.0	= 4.0	5.0 to 14.0	= 9.0	5.0 to 14.0	= 9.0	5.0 to 14.0	= 9.0	5.0 to 14.0	= 9.0
Totals		100.0		100.0		100.0		100.0		100.0		100.0		100.0		100.0		100.0
Total acids	65.0	= 1.86 to 1.00	60.0	= 1.50 to 1.00	50.0	= 1.00 to 1.00	42.0	= 0.725 to 1.00	40.0	= 0.666 to 1.00	30.0	= 0.43 to 1.00	30.0	= 0.43 to 1.00	30.0	= 0.43 to 1.00	28.0	= 0.39 to 1.00
Total bases	35.0		40.0		50.0		58.0		60.0		70.0		70.0		70.0		72.0	
Approximate finishing temperature °C.	1500 to 1600		1400 to 1500		1400 to 1500		1200 to 1300		1200 to 1300		1400 to 1500		1400 to 1500		1400 to 1500		1500 to 1600	
Mechanical losses of non-recovered metal, per cent of charged weight	Direct metal 6 Duplex 4		2 (cold pig and scrap)						2		4 (direct metal) 3 (cold pig and scrap)						Direct metal 6 Duplex 4	

TABLE II.

	C	Si	P	Mn	
1. Hematite—mixed Nos.	3.80	2.50	0.06	1.00	Natural hematite iron
2. Hematite—special....	3.20	1.00	0.06	0.80	Special hematite (American "Bessemer")
3. Common forge.....	3.50	1.80	1.50	0.60	Natural iron (Cleveland, Northants)
4. Common basic.....	3.20	1.00	1.25	1.20	Low-silicon iron with proportion of foreign ores
5. "Thomas" special....	3.20	0.50	0.50	2.25	Continental — high phosphorus and manganese

TABLE III.

Duplex Hot Metal Processes (Common Forge)	Preliminary			Basic Open-Hearth Finishing Furnace			Combined		
	Mixer	Acid Bess.	Basic Bess.	Mixer	Acid Bess.	Basic Bess.	Mixer	Acid Bess.	Basic Bess.
Lime.....	4.4	1.21	4.5	8.45	7.5	7.3	13.0	8.0	11.2
Oxides.....	11.6	....	....	19.1	13.6	14.45	31.1	12.2	13.2
Yield.....	102.2	89.8	91.4	102.8	101.3	101.3	105.1	91.0	92.8
Slag make....	9.4	8.10	9.6	16.9	15.0	14.6	17.3	13.5	13.4
Slag P_2O_5 per cent..	1.2	....	1.1	19.7	22.8	22.7	19.7	22.8	22.7

0.4 per cent is evidence that Fe_2O_3 is extremely active as an oxidizing agent, even producing much free oxygen during heavy oreing. It is also continuously formed on the slag surface by furnace gases, as shown by the gradual thickening of the slag during the quiet finishing stage, when carbon in the bath is removed slowly with concurrent increase of Fe_2O_3 from say 0.2 to 2.0 per cent in the slag.

Several decarburizing reactions may be written. Consider

$$FeO + C = CO + Fe$$

This takes place at very slow rate, since when ore is added to the furnace Fe_2O_3 is destroyed and FeO rapidly increased. Again, 0.86 metal held 2 hr. under a slag containing 24 per cent FeO dropped to only 0.38 per cent C, with a corresponding decrease of FeO to but 20.8 per cent; calculation showing a large portion of the decarburization to be unaccounted for by the change FeO $\longrightarrow$ Fe

The reaction

$$Fe_2O_3 + Fe = 3\ FeO$$

is the only plausible reaction in which the percentage of iron in a slag can be raised. Since this actually occurs in the finishing stages, when C is below 0.15, it possibly is the predominant reaction. It doubtless also occurs during the boil, counteracting somewhat the effect of the then more prominent reaction

$$Fe_2O_3 + 3\ C = 3\ CO + 2\ Fe$$

or possibly $Fe_2O_3 + C = CO + 2\ FeO$

The authors conclude that the rapid reduction in carbon is due to gas reduction either direct or by Fe_2O_3 acting as a carrier; the latter being formed on the surface layers of the slag, and reacting with the slag-iron interface, most particularly of metal shot dancing in the slag whose quantity equals ½ ton in a 100-ton bath. Therefore the use of a rich gas with as much air as the furnace can carry will afford best conditions for carbon removal—that is, rapid thickening of slag after more frequent ore additions. Consideration of the rate at which the bath is decarbonized after the boil (entirely by Fe_2O_3), and during the boil, also leads to the assumption that perhaps ½ of the decarbonization by gas-reduction is due to contact between gas and metal shot during the boiling period.

Modern Steel Metallurgy

Mr. C. H. F. Bagley, technical supervisor for the South Durham Steel Co., presented a discussion of "Modern Steel Metallurgy," a calculation and comparison of processes, particularly as refers to the slags formed. In brief, it is a treatise on the metallurgical calculations of steel-furnace slags, so collated that given unit prices for different qualities of the necessary constituents, the the best combination for any modern process may be actually determined with confidence, or, on the other hand, the best process for a given set of conditions may be found when planning a new works. The author pays particular attention to the slag produced, laying emphasis upon the fact that steel making also involves slag making, and, other things being equal, it is true that any factor which lessens the quantity of slag made will at the same time increase the output of iron and lower its cost.

There is nothing particularly novel in the method of calculations. In general, given the analysis of metal charged and the amount of metal tapped, the amount of oxidation can easily be figured. Oxygen comes either from blast or ore; in the latter case, additional slag-forming impurities are added. These, with the impurities from the bath, will form a slag which in a given process varies within rather narrow limits at the end of the operation (whatever it may have been meanwhile) in order that it may be thin enough to pour, quiet, stable and non-corrosive. From such known composition, and a little auxiliary data as to mechanical losses, a metallic and non-metallic balance sheet can easily be obtained, giving the yield in metal per unit charged, the slag make and the weight of all additions.

Principal data are assembled in Tables I and II. As an instance of the results Table III summarizes the author's calculations on the various styles of duplex processes.

Lignite Utilization Board of Canada

Although Canada possesses large coal deposits, it has been necessary to import about 500,000 tons of anthracite from Pennsylvania at a cost of about $5,000,000 per annum. The lignite deposits underlying various districts of the Provinces of Saskatchewan and Alberta are unsuited in the raw state to household use. By carbonizing, however, a coke is obtained which briquettes readily; two tons of the inferior fuel giving one ton of briquettes which approximate anthracite in heating value.

The Lignite Utilization Board was created to investigate machines and processes for carbonizing, briquetting, etc., and to construct a plant of commercial size for the production of domestic fuel. Consideration will also be given to the utilization of by-products and of powdered fuel for commercial power production.

Ramsay Memorial Fund

The committee for the *Ramsay Memorial Fund* for the United States reports the receipt of contributions totaling $4700, which, after deduction of current expenses for printing, postage, etc., will leave about £900 for transmission to the Fund headquarters in London. The committee had hoped to be able to transmit at least £1500 at this time, and will therefore welcome further contributions. Checks should be sent to the chairman, Dr. Charles Baskerville, 140th St. and Convent Ave., New York, or to the treasurer, Mr. William J. Matheson, 21 Burling Slip, New York.

Synopsis of Recent Chemical and Metallurgical Literature

Copper in Slags—A very important contribution to our knowledge as to the exact condition in which copper is held in furnace slags appeared in *Engineering and Mining Journal* for May 10, 1919, Volume 107, page 815, from the pens of C. G. MAIER and G. D. VAN ARSDALE. Their investigations were confined exclusively to Phelps-Dodge slag when making a 30 to 40 per cent matte by smelting raw or roasted sulphides. Microscopically, such matte shows FeS islands in Cu_2S, ground mass, as in the globule of Fig. 6. Silver-nitrate is a good etching agent, deeply corroding the Cu_2S, which fact is utilized in determining whether any copper sulphide is present as a true solution in the slag. Under a microscope this reagent showed no effect on slag, while it actually dissolved more than 98 per cent of the copper from mattes and white metal. The equation is probably

FIG. 6. BLAST-FURNACE SLAG. CHILLED UNETCHED INCLUSION IS UNALTERED MATTE. × 35

$$Cu_2S + 4AgNO_3 = 2Cu(NO_3)_2 + 2Ag + Ag_2S$$

Analyses of several blast-furnace and reverberatory slags showed an average residue of 0.7 per cent copper insoluble in $AgNO_3$, with an average deviation of only 0.11, which figure (0.7 per cent) possibly represents the maximum solubility of some copper compound in such slags as 36 per cent SiO_2, 10 per cent Al_2O_3, 34 to 42 per cent FeO, 4 to 18 per cent CaO + MgO.

Table I shows various possible forms whereby copper may be held in slags.

Since no oxidized copper minerals were found in crystallized samples, and also since the copper dissolved in slags appeared to be a constant quantity, it is probable that no copper is held in solution as oxide. When remelting slag with various proportions of cupriferous pyrite as plotted in Fig. 3, the per cent of copper in the resulting slag was quickly reduced to the amount originally held in solution. It is therefore probable that copper is not dissolved as metal, because the addition of pyrite already saturated with Cu_2S does not change the total in solution in the slag as would then be expected by the sulphidizing action of the pyrite. The addition of copper-free pyrite shown in the middle curve

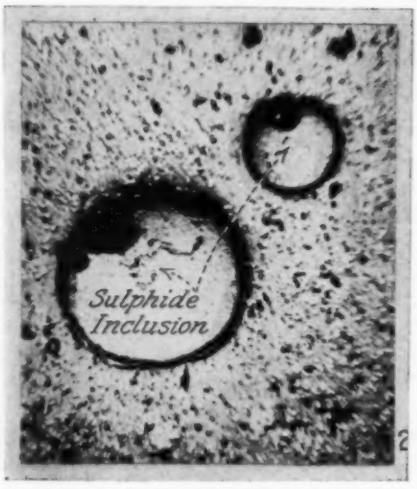


FIG. 2. CONVERTER SLAG, UNETCHED. FLOTATIVE EFFECT OF BUBBLES INDICATED BY CO-PLANAR OCCURRENCE. × 150

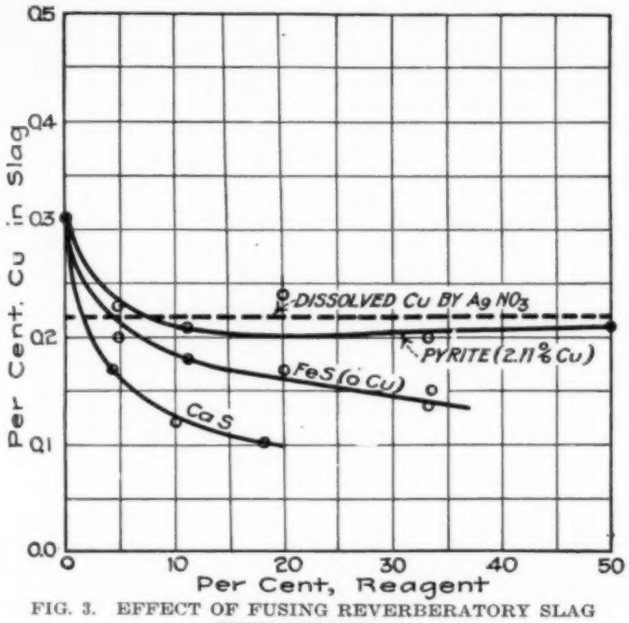


FIG. 3. EFFECT OF FUSING REVERBERATORY SLAG WITH SULPHIDES

TABLE I. COPPER IN SLAGS

Microscopically	Visible				Invisible							
Physical Forms	Group 1 Macro / Micro scopic particles				Group 2 Ultramicroscopic particles / Colloidal solution			Group 3 True Solutions				
Possible Forms	(Matte)	Cu_2S	Cu	Dissolved in FeS	(a) Matte	Cu_2S	Cu Oxides and Silicates	Cu_2S	Cu and Oxides	Cu_2O / CuO	(SiO_2)	Cu_2O / CuO / Fe_2O_3 / Al_2O_3
Actual occurrence as observed or concluded	Occasional	Usual	Seldom, oxides or silicates not observed	If so, very small in amount	Very improbable	Probable	Improbable	Probable	Improbable	Improbable		Improbable
Indicated lines for experiment	Settling by control: Temperature / Density / Viscosity. Prevention of flotation.				Coagulation and Settling			Salting out: By variation of constitution. By additional agents				

(a) Matte is a variable complex material containing at least two constituents, one of which is readily attacked by Fe_2O_3, and it is not proper to speak of its solubility as such. There must also, therefore, be a limiting size to the matte particles, below which they cannot exist in suspension.

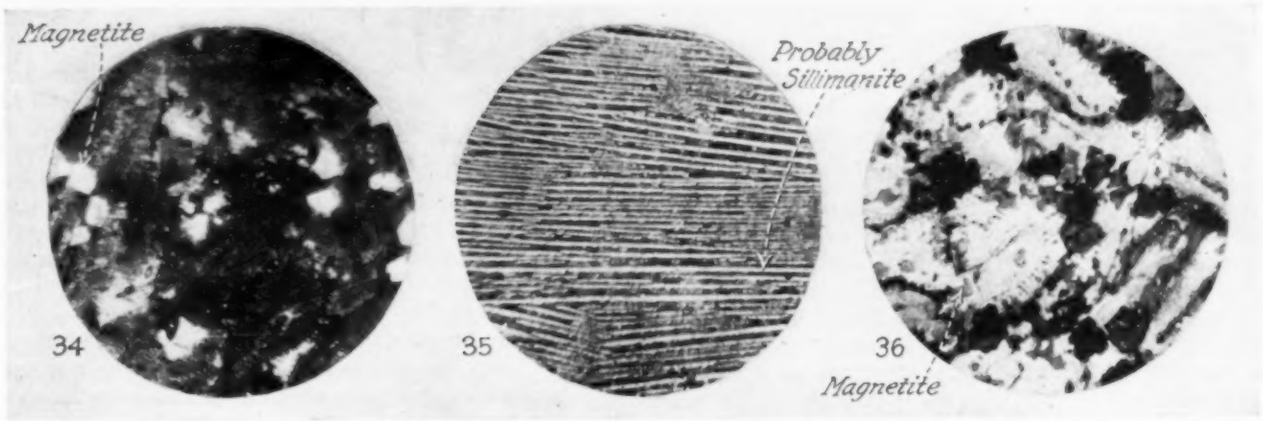


FIG. 34. REVERBERATORY SLAG, ETCHED WITH HF. FUZZY CRYSTALLINE EDGES SHOW SEPARATION OF Fe_2O_3. × 380. FIG. 35. WELL CRYSTALLIZED BLAST-FURNACE SLAG, ETCHED WITH HF COLUMNAR CRYSTALS WITH NO MAGNETITE. FIG. 36. FIRST-SKIM CONVERTER SLAG; HEAT-TINTED

reduces the dissolved copper, now assumed to be copper sulphide because of the distribution effect between slag and sulphide phase, and the idea that the copper is held as Cu_2S is further reinforced since the addition of CaS reduces the total copper because it increases the concentration of a common ion—in this case sulphur. The

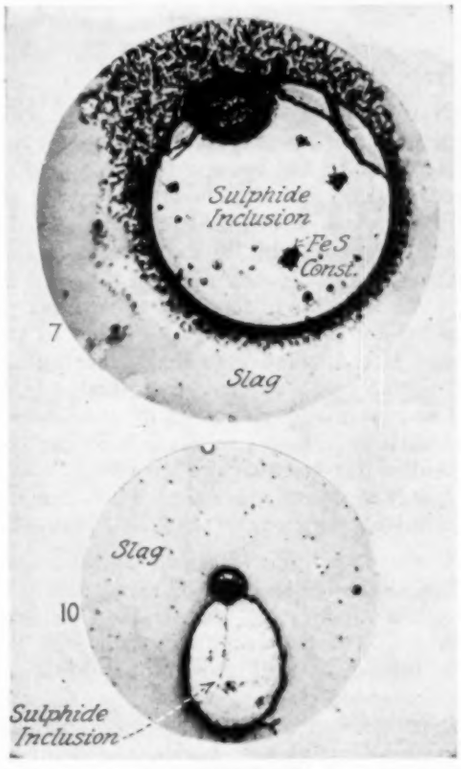


FIG. 7. CHILLED BLAST-FURNACE SLAG; INCLUSION WITH LITTLE FeS. × 35. FIG. 10. CHILLED BLAST-FURNACE SLAG; FeS CONSTITUENT ELIMINATED; WELL DEVELOPED GAS BUBBLES. × 150

actual nature of this soluble sulphide is not known, but it very likely contains little FeS, because the latter ordinarily tends to disappear in the microscopic globules observed—in other words the shot of typical matte shown in Fig. 6 is usually replaced by spherical inclusions such as Fig. 7 or 10, where the FeS has largely disappeared, thus leaving particles of Cu_2S containing more or less FeS in solution. Iron sulphide constituent is not commonly observed even in slags from high grade matte.

Gas bubbles appear to be attached to the inclusions

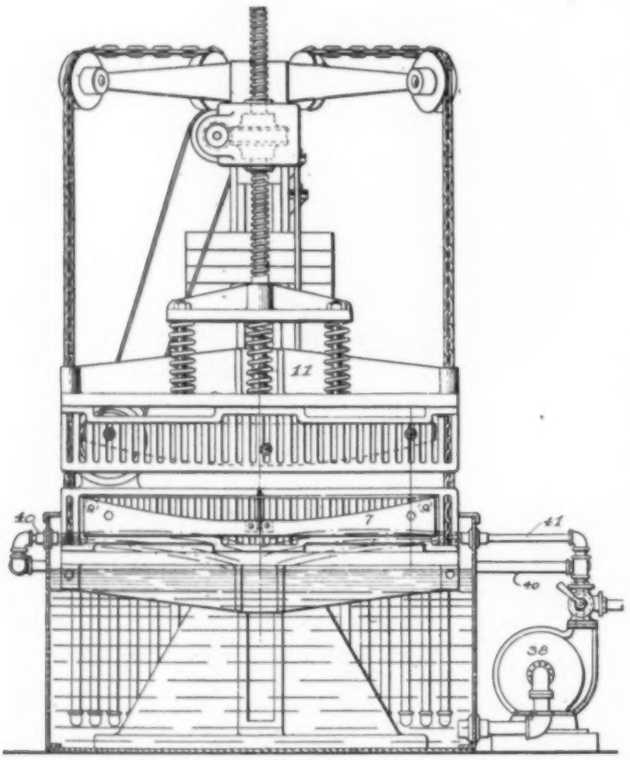
FIG. 27. REVERBERATORY SLAG, ETCHED WITH NaOH. × 150

shown in Figs. 7, 10 and 2, and the authors believe that this gas is derived from the disappearing FeS according to the reaction $FeS + 3Fe_2O_3 = SO_2 + 7FeO$. Of course, FeS might settle out physically as shown in Fig. 6, but this is never complete and occurs only at a narrow range of temperatures giving a mushy state. From microscopic evidence, the authors conclude that, since gas bubbles accompany the disappearance of FeS, the gas is probably SO_2. It is logical to assume that Fe_2O_3 is the oxidizing agent since ferrous oxide and dissolved air would produce metallic iron and copper, respectively, neither of which was found. Ferric oxide is present, since it is required to form the magnetite ordinarily present in furnace slag. Magnetite occurs in converter slags in allotriomorphic crystals shown in Fig. 36. Magnetite is also present in reverberatory slags in holomorphic crystals often with fringes of dark colored Fe_2O_3 (Fig. 34), or in dendritic form (Fig. 27). However, magnetite was not found by these authors in their blast-furnace slags, whose structure is represented by Fig. 35.

Apparently, therefore, copper is held in furnace slags to a certain small extent as a true solution of sulphide, while the balance occurs as globules of white metal floated by attached gas bubbles. Continued settling would not appear to reduce the quantity of the latter, which could only be done by changing the composition of the slag so as to practically eliminate the occurrence of ferric oxide. Converter slags may contain as high as 0.5 per cent of copper in true solution, with the balance present as particles of white metal. As the blow continues the soluble copper continually decreases. Here is additional evidence that practically no copper silicates are formed in normal furnace practice.

Recent Chemical and Metallurgical Patents

Automatic Hardener.—T. J. FAY of Brooklyn, N. Y., has patented a special machine, illustrated herewith, designed for the automatic cambering and heat treatment of such parts as spring leaves. A heated plate of spring steel containing about 1 per cent carbon is heated to about 1535 deg. F., and placed on the lower anvil 7. The recessed upper head 11 then descends, shaping the bar to the desired radius. The entire assembly then descends past the oil sprays 40 and 41 into the tank below, which contain an oil layer 12 in. thick, resting upon a body of water. The passage of the oil layer requires 3 sec. when the hot metal is held in the water for 57 seconds. After this time the mechanism is elevated out of the fluid, and



AUTOMATIC HARDENER

the cool, cambered bar removed from the machine. The temperature of the metal and the relative time it is held in oil and water are subject to variation depending upon the kind of metal being treated. The entire equipment is electrically driven and by means of time relays the proper intervals can be absolutely fixed and repeated, so that at the end of the operation the core of the leaf will contain enough residual heat so that it may be properly annealed by blooming. (1,298,682; assigned to Standard Parts Co., Apr. 1, 1919.)

Ignition of D. & L. Cake.—C. W. ADAMS of Murray, Utah, notes that many times the usual oil-flame ignition for a Dwight & Lloyd sinter cake is not entirely satisfactory. In some cases such intense ignition fuses a crust on the top of the ore, making the charge semi-impervious to the passage of oxygen. This causes elemental sulphur to distill into the flues, giving rise to the danger of explosive combustion. High loss in lead and silver is also characteristic of such practice. The inventor proposes to ignite the cake by spreading a thin layer of hot calcine on it. One-half inch of a bright red calcine having 12 to 15 per cent sulphur content has been satisfactorily used and has been found to obviate the disadvantages attending high-temperature ignition. For ease it is suggested that the hot calcine be discharged from a roasting furnace placed directly above the sintering machine. (1,299,892; assigned to American Smelting & Refining Co., Apr. 8, 1919.)

Resistors for Electric Furnace.—H. G. WEIDENTHAL of Cleveland, Ohio, suggests a novel arrangement for an electric furnace, whereby gangs of parallel, vertical resistors form the inner lining of the furnace laboratory. These terminate below in a conductor placed below a refractory hearth, which is banked up somewhat above their lower ends, and above are clamped to a conducting bar, in such a way that any damaged individual may be easily removed. Resistor gangs are so arranged as to allow spaces for pouring spout, and charging and inspection doors. For the individual resistors the inventor suggests molded rods of carborundum sand, coated with crystalline corborundum. At least one of each gang must have a small conducting rod in its axis, so as to start the current through the carborundum, which has a high resistance when cold. (1,304,425, assigned to J. H. Herron Co.; May 20, 1919).

Converter Puncher.—CHARLES J. ARCH of Douglas, Ariz., has patented an automatic device for punching tuyeres in a copper converter. It consists of a frame carrying several air cylinders, one lined up for each tuyere, and with valves interlinked in a train so that each tuyere shall be punched by the piston rods in succession upon starting the first. Any plugged tuyere can also be skipped. Removable piston-rod ends are provided against wear, and a circular scraper is placed some distance ahead of the cylinder so that adhering slag may be peeled off the rod. The entire apparatus is counterweighted and normally connected by side arms to the connector shell and it tilts in a circle as the converter moves. Automatic releases are provided, however, so that the puncher is left stationary when the converter passes a limiting position. (1,303,755, May 13, 1919.)

Electrolytic Tungsten.—Present methods of drawing hot tungsten wire through diamond dies lubricated with graphite form an undesirable carbide alloy. F. G. KEYES of Cambridge, Mass., finds that WO_3 will dissolve in boric acid at 1200 to 1400 deg. C., and may then be electrodeposited upon, say, a fine tungsten wire. When the deposit has grown to sufficient size it will be found somewhat ductile and can be drawn through dies of high-speed steel lubricated with talc (1,293,117; assigned to Cooper Hewitt Electric Co., Feb. 4, 1919.)

Crucibles.—F. J. TONE of Niagara Falls. has discovered that a very excellent crucible for melting metals can be made of 40 per cent graphite ground to 16 mesh, 40 per cent commercial magnesia, sintered in the electric furnace and ground to 40 mesh, and 20 per cent plastic refractory clay. This forms a plastic mass which can be made into crucibles and fired in the ordinary manner, and produces a superior, tough article which resists scaling or slabbing under heat variation in a superior manner. (1,303,993; May 20, 1919.)

Detinning Process.—WALTER ZACHARIAS of Pittsburgh, Pa., has discovered that when dry tin scrap is treated with chlorine, the reaction forming $SnCl_4$ starts at local points when the concentration reaches a rather high figure, but rapidly spreads to all parts of the mass by the liberated heat. In order to prevent unduly high temperatures (which form undesirable iron chlorides) and loss in excess chlorine, he proposes to start the reaction when only low concentrations of chlorine are present by the addition of finely powdered metallic tin, which by virtue of its high specific surface will react at low temperatures and concentrations. He also proposes to place a hopper containing powdered tin above a suitable opening in the detinning vessel, so that this reagent can be introduced at will to regulate the temperature within, and to avoid the loss in time, chlorine, iron and tin chloride certain to follow undue irregularities. (1,283,016; Oct. 29, 1918.)

Improvements to Electric Furnaces.—W. E. MOORE of Pittsburgh, Pa., patents features designed to improve mechanical operation of electric furnaces. For instance, he recommends an arched bottom plate so that local heating may not destroy the furnace lining by buckling. A tilting arrangement consisting of stationary traction rollers, gear driven, is also suggested. Electrode holders should also be mounted at the side of the

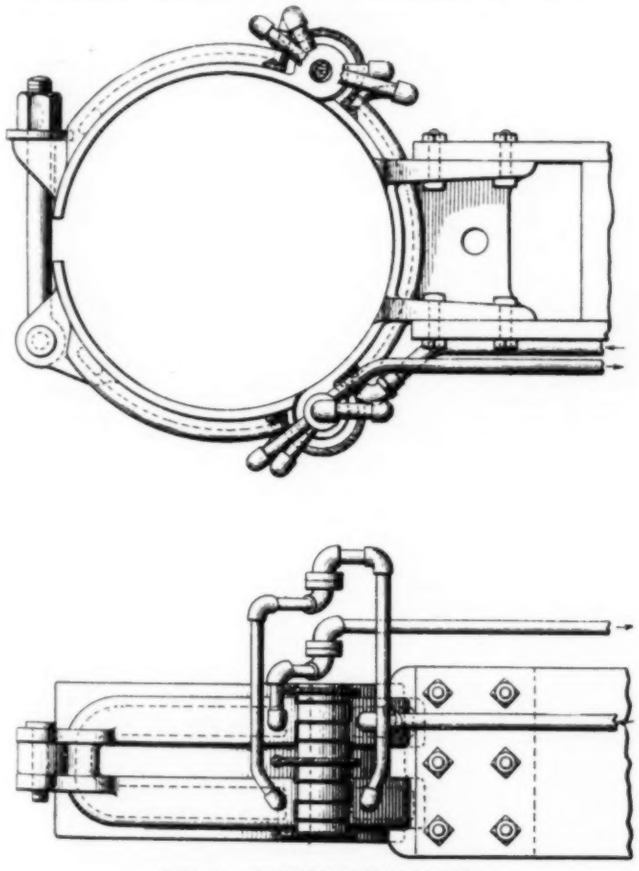


FIG. 1. ELECTRODE HOLDER

furnace and capable of rotation about the axis of their supporting column, so that they may be swung away from the furnace roof when renewing roof or electrode. This arrangement also allows the hoisting chains to be drawn together to a point near the tilting center of the furnace, and thence leading them off to any convenient location for the motors. Electrode holders and arms themselves should preferably be split and hinged somewhat as shown in Fig. 1, to provide for the variation in sizes of carbons. Improved door and spout construction is also described. (1,304,350; May 20, 1919.)

Blast-Furnace Uptakes.—JULIAN KENNEDY of Pittsburgh, Pa., patents a blast-furnace top construction shown in Fig 2, involving inclined uptakes (6) discharging through restricted openings (10) into a downcomer branch (8), which latter connects with a similar set on

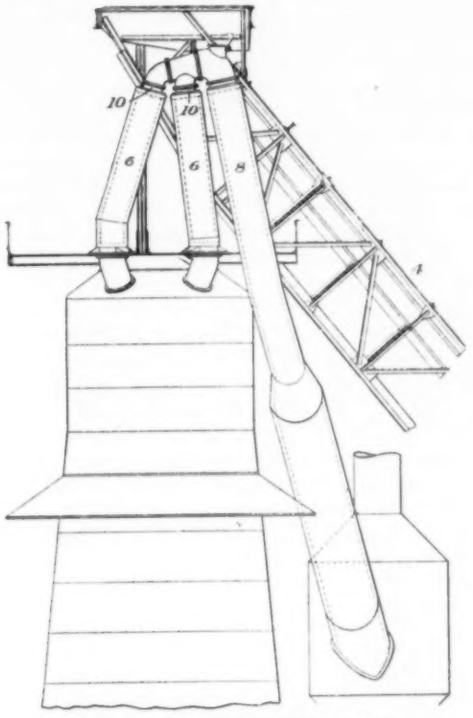


FIG. 2. BLAST-FURNACE TOP

the other side of the skip-bridge (4). This construction is proposed in order that a considerable proportion of the dust taken off by furnace gases or explosions may be arrested and fall back into the furnace proper before passing into the downtake. (1,303,914; May 20, 1919.)

Preparation of Iron Ore.—W. G. SWART of Duluth, Minn., and B. G. KLUGH of Anniston, Ala., note that certain fine or clay-bearing iron ores or concentrates, or high-sulphur ores, must be agglomerated before use in blast-furnaces. Commercially such agglomeration is best performed on an intimate mixture of fine ore and solid fuel, with sufficient water to make it plastic. Mixing of such wet, sticky masses is extremely difficult and expensive, and the inventors propose to take unwatered concentrates (or make up a thin pulp of the iron-bearing material), add dry pulverized coal or even wet peat, agitate thoroughly, and then filter the now well-mixed mass on a continuous filter so operated that the resulting cake shall have the proper proportion of moisture for sintering. (1,303,411, May 13, 1919.)

Lactic Acid.—By digesting sawdust with a solution of lactic acid, GEORGE A. RICHTER of Berlin, N. H., obtains a mixture containing reducing sugars. After filtering, the solution is treated with an excess of calcium carbonate and fermented by lactic acid bacteria. The excess $CaCO_3$ serves to neutralize the lactic acid as rapidly as it is formed during fermentation. Sufficient sulphuric acid is added to precipitate all the calcium as sulphate, which is filtered off, leaving a solution of lactic acid. (1,305,623; assigned to the Brown Company; June 3, 1919.)

Personal

The Salt Lake office of CHEMICAL & METALLURGICAL ENGINEERING has been closed and transferred to Rialto Building, San Francisco, Cal. Mr. Ernest E. Thum, formerly Western Editor, will be transferred to New York City as associate editor and Mr. L. W. Chapman, formerly with the Anaconda and duPont organizations, will go to San Francisco as Western editor.

DR. RAYMOND F. BACON, Director of the Mellon Institute of Industrial Research, received the honorary degree of Doctor of Science, on the occasion of the annual commencement of De Pauw University, Greencastle, Indiana, on June

DR. H. K. BENSON has received his discharge as a captain in the research section of the nitrate division of the Army Ordnance and has returned to the University of Washington, Seattle, to resume his work as professor of chemical engineering and administrative head of the Department of Chemistry.

MR. FRANCIS S. BOSQUI will shortly open his office as metallurgical engineer at 90 West Street, New York City.

MAJOR ARTHUR S. DWIGHT, 11th Engineers, has recently returned to civil life after two years service in France with the A. E. F. On June 26 he addressed the New York Section of the A. I. M. E. on his war experiences.

MR. ELLWOOD HENDRICK, consulting editor of CHEMICAL & METALLURGICAL ENGINEERING, expects to sail for Venezuela, Wednesday, July 2.

COL. G. A. BURRELL has received the Distinguished Service Medal for his work as chief of the research Division, Chemical Warfare Service, during the war.

DR. VANNOY H. MANNING, director of the United States Bureau of Mines, on the occasion of the annual commencement of the University of Pittsburgh on June 13, received the honorary degree of Doctor of Engineering, in recognition of his noteworthy accomplishments in the investigation of problems of mineral technology. The university also conferred the honorary degree of Doctor of Chemistry upon DR. WILLIS R. WHITNEY, director of the Research Laboratory of the General Electric Co., Schenectady, New York, because of the valuable service which he rendered to the Government as a member of the Naval Consulting Board. These honorary degrees were given upon the recommendation of the Mellon Institute of Industrial Research, an integral part of the University of Pittsburgh.

PROFESSORS W. A. PATRICK and M. E. REID of the chemical department of the Johns Hopkins University will act as consulting chemists for the du Pont organization during part of the vacation period.

DR. J. W. RICHARDS, professor of metallurgy in Lehigh University and secretary of the American Electrochemical Society, leaves New York July 3 for Norway. After visiting some electrochemical plants in Norway and Sweden, and his son in Copenhagen, Dr. Richards will return about the middle of September.

MR. E. H. ROBIE, recently assistant metallurgist for the Canadian Copper Co., Copper Cliff, Canada, has joined the editorial staff of *Engineering and Mining Journal*.

DR. JULIUS STIEGLITZ has been appointed chairman of the advisory committee on synthetic drugs to the Chemical Foundation, Inc., New York.

MESSRS. THORNE L. WHEELER and JOHN C. WOODRUFF have formed a partnership for the general practice of chemical engineering under the firm name of Wheeler & Woodruff, with offices at 280 Madison Ave., New York.

MR. EDWARD S. WIARD has resigned as consulting engineer for the Colorado Central Mines Co. and the Anondaga Mines Co. and will resume regular practice at 409 Boston Bldg., Denver, Colo.

MR. HORACE V. WINCHELL, president of the American Institute of Mining and Metallurgical Engineers, recently addressed the New York Section on the new developments at the Eastern end of the Mesabi Range in Minnesota.

Book Reviews

BOILER CHEMISTRY AND FEED WATER SUPPLIES. By *J. H. Paul*. 242 pages, illustrated. New York: Longmans, Green and Co.

The author has included a great amount of original data taken from his own experience. The book is written with the point of view of the usual technical training of the average power engineer in mind. Boiler chemistry is mainly concerned with the innumerable reactions that take place when natural waters are heated to around 400 deg. F. under a pressure of fifteen to twenty atmospheres. The chapter on water softening processes is too limited in scope. The book will serve a long neglected field and should be read by all engineers concerned with steam engineering.

WALLACE SAVAGE.

Current Market Reports

The Non-Ferrous Metal Market

Tuesday, June 24.—The prospects of the signing of the Peace Terms as well as the summer impetus toward increased construction work have greatly strengthened the metal market. Prices that had declined are now rising.

Aluminum:—No variation from the 33c. per lb. price on 98-99 per cent ingots is reported. Scrap sales are equally stable: Cast, 20-23c.; sheet, 20-23c., and clippings, 22½-26c. Sheets, 18 gage and heavier, 42c. Powder, $0.70-1.40 lb.

Antimony:—There is a slight shortage in antimony supplies, wholesale spot bringing 8¾c. and future 8-8¼c. lb. Job lots, 8⅝c. lb.

Copper:—The copper market is showing considerable strength with 18c. lb. for spot and 18¼c. for August futures. Predictions of 20c. copper are being made.

Copper sheets, hot-rolled	lb.	$0.25½ —	.....
Copper sheets, cold rolled	lb.	.26½ —	.....
Copper bottoms	lb.	.25 —	.....
Copper rods	lb.	.19 —	.....
Copper wire	lb.	.18½ —	$0.19
High brass wire and sheets	lb.	.20½ —	.....
High brass rods	lb.	.19½ —	.....
Low brass wire and sheets	lb.	.20½ —	.....
Low brass rods	lb.	.22½ —	.....
Brazed brass tubing	lb.	.31½ —	.....
Brazed bronze tubing	lb.	.36 —	.....
Seamless copper tubing	lb.	.30 —	.....
Seamless bronze tubing	lb.	.36 —	.....
Seamless brass tubing	lb.	.29 —	.....
Bronze (gold) powder	lb.	1.00 —	.....

Lead:—Lead has advanced 0.15c. and spot New York is 5.4s. and St. Louis 5.15c. Sheet lead, 8.5c. lb.

Tin:—Spot tin is quoted at 71c. lb. and August futures, 52c. Trading in tin will start in the New York Metal Exchange on July 7.

Zinc:—July spelter is bringing 7.15c. in New York and 7c. in E. St. Louis.

OTHER METALS

Bismuth	lb.	$3.20 —	$3.65
Cadmium	lb.	1.40 —	.....
Cobalt	lb.	2.50 —	3.50
Magnesium	lb.	1.75 —	2.10
Mercury	75 lb.	95.00 —	.....
Nickel	lb.	.40 —	.45
Iridium	oz.	175.00 —	.....
Palladium	oz.	115.00 —	120.00
Platinum	oz.	105.00 —	.....
Silver	oz.	1.11½ —	.....

The Iron and Steel Market

The key to the steel market's future is the relation between the buying of steel for ordinary everyday consumption and the buying of steel for construction purposes or permanent investment. Such claims as have been made that the outlook is unfavorable have been based on a view that buying of steel for permanent or prolonged use, in other words for investment, is abnormally small, but such an argument defeats its own end, for it that were true the buying that has been in progress has been purely for current consumption, and that buying has lately represented more than 60 per cent. of the productive capacity.

The accepted estimate, however, is that normally more than 50 per cent. of the steel passes into permanent use. One of two things is the case. Either the current needs of the country have tremendously increased, so as to represent more than 60 per cent. of the capacity. or there really has been at least a moderate amount of buying of steel for permanent use or investment. In either case the steel outlook is obviously favorable, for buying for current use would naturally increase as unsettlement due to the war's ending passes, and buying for investment purposes is certain to come, or to increase. Investments must be made, for large quantities of capital have accumulated, awaiting investment, and steel in the form in which it leaves the mills is cheap, since finished steel products are now about 80 per cent. above their ten-year pre-war average, whereas the Dun and Bradstreet index numbers, covering commodities in general, stand at double their ten-year pre-war averages. Thus commodities in general will buy more steel than formerly. Steel has been affected less by the expansion, commonly though unfortunately called "inflation," than have commodities in general. Hence, when investments must be made, investment in steel is particularly attractive.

Effects of Peace Treaty

While a great many views that were entertained just before and after the signing of the armistice have had to be modified, there is among others one view then entertained that has molded men's conduct, whereby light upon the future is thrown. That view was that investment would not proceed freely until the peace treaty should be signed. There can be no doubt that investments, particularly in works of construction, have been held back awaiting the formal establishment of peace by the signing of the treaty. The view that there would be an immediate or at least a prompt "deflation" in prices has been discarded, but the holding of the view for so long operated to delay the conversion of liquid capital into works of construction for investment purposes, involving the purchase of commodities and employment of labor.

It is true that some investors might be expected to anticipate the arrival of the formal peace, but the fact that as the months after the armistice passed, peace, with stable governments in Europe, seemed to recede instead of approach, had a tendency to discourage investors. Furthermore, many investments or undertakings rest upon the vote of boards of directors, many of the members being indisposed to anticipate, but to follow one plain policy, of refusing to endorse new ventures until peace should be sealed by the signing of the formal treaty by responsible and stable governments. That event having occurred, a great many new ventures will undoubtedly be launched quickly.

New Construction

By no means, however, has the inception of new construction awaited this time. By far the most accurate index to new construction such as particularly interests the steel trade is the monthly compilation of the Bridge Builders' and Structural Society of the amount of fabricated steel work let to the fabricating shops. In terms of monthly fabricating capacity the bookings have been as follows: January, 12 per cent; February, 12½ per cent; March, 17½ per cent; April, 24½ per cent; May, 49 per cent. When the volume of this business doubled from April to May it seems altogether reasonable to conclude that the signing of the peace treaty will result in a very large further increase.

There has been a curious reversal in the outlook as to the time when various new enterprises would be undertaken. Assuming, as practically everyone did, that a large quantity of construction work had piled up, the reasonable view not long ago, when it was expected that construction costs would gradually decline, was that the work undertaken first would be the more pressing work, that in which first cost was the less important consideration and time the more important, so that as time passed one class of work after another would be undertaken. Now, however, when the common view is that construction costs are approximately as low as they are likely to be for several years, with possibilities that they will increase, the majority of investors are likely to be disposed to take hold at once. Their activities will be limited not so much by fear that the passage of time would write a depreciation on investments through construction costs declining as by inability to secure steel deliveries or labor with which to put the steel into employment. A rapid rather than a slow recovery in steel is therefore to be expected.

Production

The low point in steel production fell at some time in May, probably about in the middle of the month, the rate, measured in steel ingot output, being down nearly if not quite to 50 per cent of capacity, the average production for the month having been 54 per cent. The computation is based upon the fact that 30 companies, which in 1918 made 84.03 per cent of the country's total steel ingots, reported 1,929,024 tons as their output in May, while the capacity of the country may be taken at 49,000,000 tons a year. The average 54 per cent rate for May compares with 65 per cent for April, 77 per cent for March, 85 per cent for Feburary and 87 per cent for January. Since this low point of about 50 per cent. there has been a steady increase, consequent upon the increase in the buying of steel that began about the second week in May, and June production may be taken as having been at about 60 per cent of capacity on an average. Apart from such inroads upon output as may be made by midsummer weather, the recent 50 per cent rate will probably stand as the low record for several years.

Prices

The test of the stability of the "regular" or "recognized" steel prices, those that became effective March 21, is the cutting that has occurred during the past three months. When with light mill operation there is no price cutting the evidence is clear that mills are afraid to cut, lest the bottom drop out of the market. Such a fear actuated the producers from the time of the armistice until April. Lately there has been price cutting in nearly all finished steel products, not by the majority of mills, but by a minority. The majority have been content to let the price cutters take such business as could be secured by that means, finding that their relations with their customers, and the service they furnish year after year, have been sufficient to bring them a very fair volume of orders, at the full prices. It seems now altogether improbable that there will be any further and general decline in steel prices. At the present time advances are not looked for, except perhaps in spots, but it is quite possible that the market will broaden so rapidly that some price advances will occur before the end of the year.

The Chemical Market

New York, June 26, 1919.

One of the most hopeful signs pointing toward a return to normality in the chemical trade is the increased domestic demand. This is attributed to the belief that the heavy stocks held by consumers when the armistice was signed have been used up.

Heavy Chemicals:—The most interesting development in the heavy chemical field is the strong position taken by caustic soda and soda ash. With the decision last week of the Alkali Export Association to advance caustic soda to $3.30 per cwt. f.a.s. a strengthening tendency immediately invaded the market. Caustic soda has been in steady demand for some time, particularly from Japan and South America, but recently, realizing that offerings in second-hands were rapidly disappearing, buyers came heavily into the market with the domestic call showing the greater strength. Soda ash is running a close second in point of demand from both export and domestic quarters, and following the example of caustic soda has registered an advance, now being quoted at $1.85-$1.90 per cwt.

The recent arrival of several thousand cases of potash from Japan, with rumors of the future heavy importation of Alsatian potash, continue the weak position of all potash products.

Muriatic and sulphuric acids are in good demand for

Cuba and South America. Last week domestic dye manufacturers were in the market for sulphuric in quantities. Citric acid is again weak due to heavy arrivals from abroad, in particular from Italy. Bleaching powder has advanced 2c, due to absorption of resale material.

COAL-TAR PRODUCTS:—The improved tone of the crudes, noted in the last writing, stands at the same level. Benzol remains firm and is meeting a heavy demand from the rubber trade. As in the case of solvent naptha, xylol, commercial, has been advanced because of heavy demand and short stocks. The same is true of phenol, with drums at 10-13c. per lb.

Intermediates are keeping their stride and as the month closes a better general business is reported from all quarters. Not only is the domestic phase on the increase, but South America is purchasing in the local market. A leading manufacturer is receiving orders for August delivery of paratoluidine and para-nitro toluol, but doubts whether he can meet the heavy July demands. Alpha-naphthylamine is hitting a good place for domestic use while H-acid is in good demand for export, not in large quantities but from a number of sources.

NAVAL STORES:—Although for a time there were no spot stocks of turpentine on the market here, owing to the heavy call from Europe—particularly Scandinavia—new supplies have meantime arrived sufficient to take care of the normal domestic demand. During the past two months London has purchased approximately 60,000 bbl., which is thought to have filled her needs. Domestic buying has fallen off due to high prices. The result is an easier market.

The principal reason for the firm tone of rosins is the heavy export demand. With only one-half the normal crop of rosins being made this year a scarcity is predicted if present buying continues. However, with the exception of the pale grades, spot stocks here are normal. Savannah, where buying is also brisk, reports a shortage of pale grades. South America and the United Kingdom are the principal operators in rosins. Other naval stores show a slight rise in sympathy with rosins.

CRUDE RUBBER:—It is estimated that present plantation stocks in London amount to 24,000 tons, with 10,000 tons in the Far East, and over 60,000 tons in the United States. In view of this condition, the market is weak, dealers being the principal operators. For the past week there has been an active dealers' demand for distant positions, presumably to cover short sales at a profit. Manufacturers, however, manifest no interest.

Paras are weak, in sympathy with planations. Manufacturers have fair-sized stocks on hand, future selling higher than spot. A Singapore cable reads: "Large holders primary markets weakening. Market weak.", while London wires: "Market stagnant awaiting political developments."

OILS:—The interrupted European demand remains the dominant factor, vegetable oils now going even into Germany and Austria. Domestic buyers realizing that the export demand will hold up the price are purchasing at prevailing levels. There is a scarcity not only of spot stocks, but of August and September futures. Linseed oil is particularly scare, owing to short crop of seed, and heavy demand. Although several shipments of seed have arrived from Argentina recently, linseed oil is firm at $1.88-$1.89 per gal.

The recent embargo placed by Spain on the export of olive oil is felt here in the small arrivals and the stiffening price. The commercial grade is held at $2.30 to $2.50 per gal.

During the past two weeks, oils, both vegetable and fish, have risen sharply. Winter pressed menhaden, quoted at the last writing at 90-92c per gal., has added 20c. to its market value. The foreign demand has developed to such an extent that surplus stocks are used up, necessitating reliance on the new catch of fish. Another factor in sending up fish oils is the fact that when these oils were at the lower level they were substituted wherever possible for the higher priced vegetable oils.

SHELLAC:—The shellac situation has not been aided by the information that the steamer "City of Rangoon," with about 5000 packages of shellac on board, had been in collision in mid-ocean with a Brazilian steamer and had put back to Gibraltar. While small amounts continue to arrive all go to fill back orders. Most dealers have stopped quoting and are merely delivering on previous sales or alloting small quantities to their regular trade. One dealer, however, is quoting orange, superfine at $1-$1.15, spot, in one and two-bag lots; futures, Sept. to Dec. deliveries, TN, 72-75c, orange, superfine, 80-85c, and bone dry at 80-85c. It is not until September that any relief is expected.

WAXES:—Firmer tone and higher prices characterize the wax market, carnauba and stearic acid showing the sharpest increase. The Brazilian crop of carnauba is exceedingly light, and trading has become speculative, with Europe buying heavily. Three shipments of this wax are expected soon, but they will have little effect, being already sold. With production cut because of the warm weather and a shortage of basic manufacturing supplies, stearic acid is scarce and higher in price. With a general shortage of spot stocks prices of waxes are expected to mount still higher.

St. Louis, Mo., June 23.

The past two weeks have shown a steadily increasing activity in most branches of the heavy chemical market, according to local producers. Demand for sulphuric acid from the fertilizer manufacturers and for sodium bisulphate or nitre cake, especially, has grown to such proportions that one of the best informed men on the subject characterized the market as having "gone crazy." Producers of nitre cake say that there is no accounting for the present demand for this item which until recently was "dumped" for indefinite storage at plants where it was a by-product. A nearby producer is understood to be digging into such a storage pile of nitre cake for the first time in years.

Sulphuric Acid—Sixty per cent sulphuric acid was the most active item on the list here in the last two weeks. This may be accounted for by the fact that producers who asked $12.50 to $14 a ton several weeks ago, on noting the reluctance to buy, accepted contracts at $11.50. Heavy sales at this figure are reported. The 66 per cent grade, still quoted at $18 a ton, is stationary, but firm. The same is true of oleum.

Muriatic Acid—A large number of sales is reported in this commodity at the quotation of the previous report, $22 a ton for the 18 per cent grade. The starch, glucose and graniteware people are alike actively in the market for the chemical.

Sodium Sulphate (Salt cake)—The demand for this item fell off during the fortnight sufficiently to induce manufacturers to offer it at a dollar concession, or $18 to $20 a ton, according to grade and quantity.

Sodium Bisulphate (Nitre Cake)—A sudden and unaccountable demand developed in the last week or two, but heavy stocks maintained the price at $4 to $5 a ton.

Nitric Acid—This branch of the market in comparison to the others is quiet. The price, however, remains firm at 10 to 10½ cents per pound for the 38 Baumé.

Zinc Chloride—In view of the conditions in railroad circles this item (used largely for treating ties) is considered fairly active by producers here. Compared to previous week, however, the demand has fallen off somewhat. The price remains stationary at 4 cents for the 50 per cent solutions.

Zinc Oxide—Developments of unusual importance are expected in the Mid-West zinc-oxide market momentarily, as a result of the action of Eastern producers in doing away with quarterly price announcements. While no definite statement of policy is forthcoming today, indications are that this market will now become wholly competitive with price changes developing from day to day or at most from week to week, rather than from quarter to quarter, as in previous years. The present quarter expires on July 1 and the basis of doing business in this item is to be readjusted within the next few days. With this condition prevailing an almost total cessation of buying would be expected. Producers, however, report an excellent demand. Prices at which current business is being done range from 8 to 9 cents a pound according to the lead-sulphate content in car lots and half a cent additional for smaller quantities. It is rumored that the inauguration of an open market will result in an advance in prices of this item.

General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET JUNE 25, 1919

Acetic anhydride	lb.	$0.52	—	$0.60
Acetone	lb.	.14	—	.15½
Acid, acetic, 28 per cent	cwt.	2.50	—	3.00
Acetic, 56 per cent	cwt.	5.50	—	6.00
Acetic, glacial, 99½ per cent, carboys	cwt.	12.00	—	14.00
Boric, crystals	lb.	.13½	—	.14½
Boric, powder	lb.	.13½	—	.14½
Hydrochloric, tech. 20 deg	cwt.	1.50	—	3.00
Hydrofluoric, 52 deg	lb.	.10	—	.11
Lactic, 44 per cent. tech	lb.	.14	—	.17
Lactic, 22 per cent. tech	lb.	.05	—	.06
Molybdic, C. P	lb.	4.50	—	5.50
Nitric, 40 deg	lb.	.07	—	.08
Nitric, 42 deg	lb.	.07	—	.08
Oxalic, crystals	lb.	.23	—	.28
Phosphoric, Ortho, 50 per cent. solution	lb.	.07½	—	.10
Picric	lb.	.30	—	.40
Pyrogallic, resublimed	lb.	2.30	—	2.55
Sulphuric, 60 deg., tank cars	ton	11.00	—	13.00
Sulphuric, 60 deg., drums	ton	17.00	—	.....
Sulphuric, 60 deg., carboys	ton	20.00	—	.....
Sulphuric, 66 deg., tank cars	ton	16.00	—	18.00
Sulphuric, 66 deg., drums	ton	21.00	—	.....
Sulphuric, 66 deg., carboys	ton	25.00	—	.....
Sulphuric, fuming, 20 per cent.(oleum) tank cars	ton	20.00	—	22.00
Sulphuric, fuming, 20 per cent.(oleum) drums	ton	25.00	—	.....
Sulphuric, fuming, 20 per cent.(oleum) carboys	ton	30.00	—	.....
Tannic, U. S. P	lb.	1.30	—	1.40
Tannic (tech.)	lb.	.42	—	.60
Tartaric, crystals	lb.	.82	—	.85
Tungstic, per lb. of WO_3	lb.	1.20	—	1.40
Alcohol, Ethyl	gal.	4.00	—	4.85
Alcohol, Methyl	gal.	1.20	—	1.23
Alum, ammonia lump	lb.	.03½	—	.04½
Alum, potash lump	lb.	.08½	—	.10
Alum, chrome lump	lb.	.15	—	.....
Aluminium sulphate, commercial	lb.	.01½	—	.03
Aluminium sulphate, iron free	lb.	.02½	—	.03
Aqua ammonia, 26 deg., drums	lb.	.06½	—	.08
Ammonia, anhydrous, cylinders (100-150 lb.)	lb.	.30	—	.....
Ammonium carbonate, powder	lb.	.12½	—	.13½
Ammonium chloride, granular(white salammoniac)	lb.	.13	—	.14
Ammonium chloride, granular(gray salammoniac)	lb.	.13	—	.14
Ammonium nitrate	lb.	.17	—	.20
Ammonium sulphate	lb.	.05	—	.06
Amyl acetate	gal.	3.50	—	3.75
Arsenic, oxide, lumps	lb.	.09	—	.09½
Arsenic, sulphide, powdered	lb.	.30	—	.32
Barium chloride	ton	80.00	—	90.00
Barium dioxide (peroxide)	lb.	.19	—	.24
Barium nitrate	lb.	.10	—	.11
Barium sulphate (precip.) (blanc fixe)	lb.	.01½	—	.03
Bleaching powder (see calcium hypochlorite)	.....	.....	—	.....
Blue Vitriol (see copper sulphate)	.....	.....	—	.....
Borax (see sodium borate)	.....	.....	—	.....
Brimstone (see sulphur, roll)	.....	.....	—	.....
Bromine	lb.	.40	—	.50
Calcium acetate	lb.	.02	—	.02½
Calcium carbide	lb.	.05½	—	.06
Calcium chloride, fused, lump	ton	19.00	—	25.00
Calcium chloride, granulated	lb.	.01½	—	.02
Calcium hypochlorite (bleaching powder)	cwt.	1.60	—	2.00
Calcium peroxide	lb.	1.50	—	1.70
Calcium phosphate, monobasic	lb.	.22	—	.23
Calcium sulphate, precipitated	lb.	.10	—	.20
Carbon bisulphide	lb.	.05½	—	.06
Carbon tetrachloride, drums	lb.	.11	—	.14
Carbonyl chloride (phosgene)	lb.	.75	—	1.00
Caustic potash (see potassium hydroxide)	.....	.....	—	.....
Caustic soda (see sodium hydroxide)	.....	.....	—	.....
Chlorine, gas, liquid-cylinders (100 lb.)	lb.	.05	—	.08
Cobalt oxide	lb.	1.60	—	1.65
Copperas (see iron sulphate)	.....	.....	—	.....
Copper carbonate, green precipitate	lb.	.28	—	.31
Copper cyanide	lb.	.65	—	.70
Copper sulphate, crystals	lb.	.07	—	.08
Cream of tartar (see potassium bitartrate)	.....	.....	—	.....
Epsom salt (see magnesium sulphate)	.....	.....	—	.....
Formaldehyde, 40 per cent	lb.	.20	—	.21
Glauber's salt (see sodium sulphate)	.....	.....	—	.....
Glycerine	lb.	.20	—	.23
Iodine, resublimed	lb.	4.25	—	4.30
Iron oxide, red	lb.	.03	—	.18
Iron sulphate (copperas)	cwt.	1.00	—	1.75
Lead acetate, normal	lb.	.12½	—	.15
Lead arsenate (paste)	lb.	.15	—	.18
Lead nitrate, crystals	lb.	.85	—	.86½
Litharge	lb.	.09½	—	.10½
Lithium carbonate	lb.	1.50	—	.....
Magnesium carbonate, technical	lb.	.12	—	.14
Magnesium sulphate, U. S. P	100 lb.	2.70	—	3.00
Magnesium sulphate, commercial	100 lb.	2.50	—	2.60
Nickel salt, double	lb.	.13	—	.15
Nickel salt, single	lb.	.11½	—	.14
Phosgene (see carbonyl chloride)	.....	.....	—	.....
Phosphorus, red	lb.	.55	—	.65
Phosphorus, yellow	lb.	.35	—	.39
Potassium bichromate	lb.	.26	—	.33
Potassium bitartrate (cream of Tartar)	lb.	.52½	—	.55
Potassium bromide, granular	lb.	.49	—	.50
Potassium carbonate, U. S. P	lb.	.60	—	.70
Potassium carbonate, crude	lb.	.11	—	.14
Potassium chlorate, crystals	lb.	.25	—	.31
Potassium cyanide, 98-99 per cent	lb.	Nominal		
Potassium hydroxide (caustic potash)	lb.	.35	—	.45
Potassium iodide	lb.	3.30	—	3.40
Potassium nitrate	lb.	.19	—	.22
Potassium permanganate	lb.	.55	—	.60
Potassium prussiate, red	lb.	.80	—	.95
Potassium prussiate, yellow	lb.	.27	—	.40
Potassium sulphate	ton	225.00	—	.....
Rochelle salts (see sodium potas. tartrate)	.....	.....	—	.....
Salammoniac (see ammonium chloride)	.....	.....	—	.....
Sal soda (see sodium carbonate)	.....	.....	—	.....
Salt cake	ton	10.00	—	15.00
Silver cyanide	oz.	1.19	—	.....
Silver nitrate	oz.	.69	—	.71
Soda ash, light	100 lb.	$1.75	—	$1.88
Soda ash, dense	100 lb.	2.00	—	2.25
Sodium acetate	lb.	.06	—	.08
Sodium bicarbonate	100 lb.	2.25	—	2.50
Sodium bichromate	lb.	.07½	—	.09
Sodium bisulphate (nitre cake)	ton	3.00	—	10.00
Sodium bisulphite	lb.	.05	—	.07
Sodium borate (borax)	lb.	.07½	—	.08
Sodium carbonate (sal soda)	100 lb.	1.30	—	1.60
Sodium chlorate	lb.	.15	—	.18
Sodium cyanide	lb.	.30	—	.31
Sodium fluoride	lb.	.14	—	.15
Sodium hydroxide (caustic soda)	100 lb.	3.00	—	3.50
Sodium molybdate	lb.	2.50	—	.....
Sodium nitrate	100 lb.	3.25	—	4.07½
Sodium nitrite	lb.	.11	—	.13
Sodium peroxide, powdered	lb.	.25	—	.30
Sodium phosphate, dibasic	lb.	.03½	—	.05
Sodium potassium tartrate (Rochelle salts)	lb.	.43	—	.45½
Sodium prussiate, yellow	lb.	.17½	—	.20
Sodium silicate, solution (40 deg.)	lb.	.01½	—	.02½
Sodium silicate, solution (60 deg.)	lb.	.02½	—	.04½
Sodium sulphate, crystals (Glauber's salts)	cwt.	1.25	—	1.50
Sodium sulphide, crystal, 60-62 per cent (conc)	lb.	.04½	—	.05
Sodium sulphite, crystals	lb.	.03½	—	.04
Strontium nitrate, crystals	lb.	.25	—	.28
Sulphur chloride	lb.	.05	—	.05½
Sulphur, crude	ton	32.00	—	35.00
Sulphur dioxide, liquid, cylinders	lb.	.10	—	.12
Sulphur (sublimed), flowers	100 lb.	3.05	—	3.60
Sulphur, roll (brimstone)	100 lb.	2.70	—	3.15
Tin bichloride (stannous)	lb.	.22½	—	.25
Tin oxide	lb.	.60	—	.....
Zinc carbonate, precipitate	lb.	.18	—	.20
Zinc chloride, gran	lb.	.12½	—	.14
Zinc cyanide	lb.	.49	—	.50
Zinc dust	lb.	.09	—	.11
Zinc oxide, dry American	lb.	.09½	—	.11½
Zinc sulphate	lb.	.03½	—	.04

Coal Tar Products

NOTE—The following prices are for original packages in large quantities:

Alpha naphthol, crude	lb.	$1.00	—	$1.10
Alpha naphthol, refined	lb.	1.40	—	1.50
Alpha naphthylamine	lb.	.35	—	.50
Aniline oil, drums extra	lb.	.22	—	.24
Aniline salts	lb.	.28	—	.33
Anthracene, 80% in drums (100 lb.)	lb.	.90	—	1.00
Benzaldehyde (f.f.c.)	lb.	1.00	—	1.15
Benzidine, base	lb.	.95	—	1.15
Benzidine, sulphate	lb.	.90	—	1.10
Benzoic acid, U. S. P	lb.	1.00	—	1.10
Benzoate of soda, U. S. P	lb.	.95	—	1.10
Benzol, pure, water-white, in drums (100 lb.)	gal.	.24	—	.28
Benzol, 90%, in drums (100 lb.)	gal.	.23½	—	.27
Benzyl chloride, 95-97%, refined	lb.	.35	—	.40
Benzyl chloride, tech	lb.	.25	—	.35
Beta naphthol benzoate	lb.	4.00	—	4.50
Beta naphthol, sublimed	lb.	.75	—	.80
Beta naphthol, tech	lb.	.45	—	.55
Beta naphthylamine, sublimed	lb.	2.25	—	2.35
Cresol, U. S. P., in drums (100 lb.)	lb.	.18	—	.....
Ortho-cresol, in drums (100 lb.)	lb.	.23	—	.25
Cresylic acid, 97-99%, straw color, in drums	gal.	.85	—	.90
Cresylic acid, 95-97%, dark, in drums	gal.	.80	—	.85
Cresylic acid, 50%, first quality, drums	gal.	.60	—	.....
Dichlorbenzol	lb.	.07	—	.10
Diethylaniline	lb.	1.50	—	2.25
Dimethylaniline	lb.	.50	—	.57
Dinitrobenzol	lb.	.25	—	.37
Dinitroclorbenzol	lb.	.25	—	.28
Dinitronaphthaline	lb.	.45	—	.55
Dinitrophenol	lb.	.30	—	.32
Dinitrotoluol	lb.	.38	—	.45
Dip oil, 25% tar acids, car lots, in drums	gal.	.38	—	.46
Diphenylamine	lb.	.70	—	.75
H-acid	lb.	1.75	—	2.25
Metaphenylenediamine	lb.	1.20	—	1.80
Monochlorbenzol	lb.	.10	—	.14
Monoethylaniline	lb.	1.50	—	1.75
Naphthaline, crushed in bbls. (250 lb.)	lb.	.06	—	.08
Naphthaline, flake	lb.	.06½	—	.07½
Naphthaline, balls	lb.	.09½	—	.10
Naphthionic acid, crude	lb.	1.00	—	1.25
Nitrobenzol	lb.	.13	—	.15
Nitro-naphthaline	lb.	.35	—	.45
Nitro-toluol	lb.	.17	—	.20
Ortho-amidophenol	lb.	6.00	—	.....
Ortho-dichlor-benzol	lb.	.15	—	.20
Ortho-nitro-phenol	lb.	1.25	—	.....
Ortho-toluidine	lb.	.37	—	.45
Ortho-nitro-toluol	lb.	.27	—	.40
Para-amidophenol, base	lb.	2.60	—	3.50
Para-amidophenol, H. Cl	lb.	2.75	—	3.25
Para-dichlor-benzol	lb.	.06	—	.10
Paranitraniline	lb.	1.00	—	1.25
Para-nitro-toluol	lb.	1.35	—	1.50
Paraphenylenediamine	lb.	3.00	—	3.25
Para toluidine	lb.	1.50	—	1.75
Phthalic anhydride	lb.	1.75	—	2.15
Phenol, U. S. P., drums (dest.), (240 lb.)	lb.	.10	—	.13
Pyridin	gal.	2.50	—	.....
Resorcin, technical	lb.	3.50	—	3.75
Resorcin, pure	lb.	6.50	—	7.75
Salicylic acid, tech., in bbls. (110 lb.)	lb.	.20	—	.30
Salicylic acid, U. S. P	lb.	.25	—	.35
Salol	lb.	.75	—	80
Solvent naphtha, water white, in drums, 100 gal.	gal.	.20	—	.27
Solvent naptha, crude, heavy, in drums, 100 gal.	gal.	.18	—	.24
Sulphanilic acid, crude	lb.	.25	—	.30
Tolidine	lb.	1.75	—	2.50
Toluidine, mixed	lb.	.45	—	.80
Toluol, in tank cars	gal.	.22	—	.24
Toluol, in drums	gal.	.23	—	.30
Xylidine, drums, 100 gal	lb.	.40	—	.45
Xylol, pure, in drums	gal.	.37	—	.45
Xylol, pure, in tank cars	gal.	.35	—	.....
Xylol, commercial, in drums, 100 gal	gal.	.23	—	.27
Xylol, commercial, in tank cars	gal.	.22	—	.....

Waxes

Prices based on original packages in large quantities.

Beeswax, natural crude, yellow	lb.	$0.42	—	$0.44
Beeswax, refined, yellow	lb.	.48	—	.50
Beeswax, white pure	lb.	.65	—	.68
Carnauba, No. 1	lb.	.88	—	.92
Carnauba, No. 2, regular	lb.	.66	—	.74
Carnauba, No. 3, North Country	lb.	.55	—	.56
Japan	lb.	.18½	—	.20
Paraffine waxes, crude match wax (white) 105-110 m.p.	lb.	.06	—	.07½
Paraffine waxes, crude, scale 124-126 m.p.	lb.	.07	—	.....
Paraffine waxes, refined, 118-120 m.p.	lb.	.08½	—	.08¾
Paraffine waxes, refined, 128-130 m.p.	lb.	.09½	—	.10
Paraffine waxes, refined, 133-135 m.p.	lb.	.11½	—	.12
Paraffine waxes, refined, 135-137 m.p.	lb.	.12½	—	.....
Stearic acid, single pressed	lb.	.20	—	.21½
Stearic acid, double pressed	lb.	.23	—	.23½
Stearic acid, triple pressed	lb.	.24	—	.25

Flotation Oils

All prices are f.o.b. New York, unless otherwise stated, and are based on carload lots. The oils in 50-gal. bbls., gross weight, 500 lb.

Pine oil, steam dist., sp. gr., 0.930-0.940	gal.	$0.70	
Pine tar oil, ref., sp. gr. 1.025-1.035	gal.	.45	
Pine tar oil, ref., sp. gr. 1.025-1.035 tank cars f.o.b. Jacksonville, Fla.	gal.	.33	
Pine tar oil, double ref., sp.gr. 0.965-0.990	gal.	.58	
Pine tar, ref., thin, sp. gr., 1.080-1.960	gal.	.34	
Turpentine, crude, sp. gr., 0.900-0.970	gal.	.61	
Hardwood oil, f.o.b. Mich., sp. gr., 0.960-0.990	gal.	.24	
Hardwood oil, f.o.b. Mich., sp. gr., 1.06-1.08	gal.	.24	
Pinewood creosote, ref	gal.	.48	

Naval Stores

The following prices are f.o.b., New Nork, for carload lots.

Rosin B-D, bbl	280 lb.	$15.00	—	$16.25
Rosin E-I	280 lb.	16.50	—	16.90
Rosin K-N	280 lb.	16.90	—	17.75
Rosin W. G.-W. W	280 lb.	17.75	—	18.60
Wood rosin, bbl	280 lb.	15.00	—	.....
Spirits of turpentine	gal.	1.10	—	.....
Wood turpentine, steam dist.	gal.	1.07	—	.....
Wood turpentine, dest. dist.	gal.	.98	—	.....
Pine tar pitch, bbl.	200 lb.	8.00	—	8.25
Tar, kiln burned, bbl. (500 lb.)	bbl.	12.50	—	13.50
Retort tar, bbl	280 lb.	13.50	—	14.50
Rosin oil, first run	gal.	.81	—	.83½
Rosin oil, second run	gal.	.83	—	.85½
Rosin oil, third run	gal.	.85	—	1.02½
Rosin oil, fourth run	gal.	.88	—	1.05

Solvents

73-76 deg., steel bbls. (85 lb.)	gal.	$0.33½	
70-72 deg., steel bbls. (85 lb.)	gal.	.31½	
68-70 deg., steel bbls. (85 lb.)	gal.	.30½	
V. M. and P. naphtha, steel bbls. (85 lb.)	gal	.23½	

Crude Rubber

Para—Upriver fine	lb.	$0.55	—0.55½	
Upriver coarse	lb.	.33	— .34	
Upriver caucho ball	lb.	.33½	— .34	
Plantation—First latex crepe	lb.	.39½	— .40½	
Ribbed smoked sheets	lb.	.38½	— .39	
Brown crepe, thin, clean	lb.	.34	— .36	
Amber crepe No. 1	lb.	.36	— .38	

Oils

VEGETABLE

Unless otherwise noted, the following prices are f.o.b., New York.

Castor oil, No. 3, in bbls	lb.	$0.19	—	$0.21
Castor oil, AA, in bbls	lb.	.21	—	.23
China wood oil, in bbls	lb.	.21	—	.22
Cocoanut oil, Ceylon grade, in bbls	lb.	.19½	—	.20
Cocoanut oil, Cochin grade, in bbls	lb.	.21	—	.22
Corn oil, crude, in bbls	lb.	.20½	—	.21
Cottonseed oil, crude (f.o.b. mill)	lb.	.19	—	.22
Cottonseed oil, summer yellow	lb.	.26	—	.27
Cottonseed oil, winter yellow	lb.	.26	—	.27
Linseed oil, raw, car lots	gal.	1.88	—	1.90
Linseed oil, raw, tank cars	gal.	1.84	—	1.90
Linseed oil, boiled, car lots	gal.	1.90	—	1.93
Olive oil, commercial	gal.	2.30	—	2.40
Palm, Lagos	lb.	.17	—	.18
Palm, bright red	lb.	.17	—	.18
Palm, Niger	lb.	.16	—	.16½
Peanut oil, crude, tank cars (f.o.b. mill)	lb.	.22	—	.23½
Peanut oil, refined, in bbls	lb.	.26	—	.27
Rapeseed oil, refined in bbls	gal.	1.55	—	1.60
Rapeseed oil, blown, in bbls	gal.	1.60	—	1.65
Soya bean oil (Manchurian), in bbls., N. Y.	lb.	.19	—	.19½
Soya bean oil, tank cars, f.o.b., Pacific coast	lb.	.16½	—	.17

FISH

Winter pressed Menhaden	gal.	$1.10	—	.....
Yellow bleached Menhaden	gal.	1.12	—	1.15
White bleached Menhaden	gal.	1.14	—	1.20
Blown Menhaden	gal.	1.18	—	1.25

Miscellaneous Materials

All Prices f.o.b., N. Y.

Barytes, domestic, white, floated	ton	$25.00	—	$36.00
Barytes, off color	ton	22.00	—	27.00
Blanc fixe, dry	lb.	.03½	—	.04½
Blanc fixe, pulp	ton	30.00	—	45.00
Casein	lb.	.16	—	.18
Chalk, English, extra light	lb.	.05	—	.07
Chalk, English, light	lb.	.04½	—	.06
Chalk, English, dense	lb.	.04	—	.05
China clay (Kaolin), imported, lump	ton	25.00	—	35.00
China clay (Kaolin), imported, powdered	ton	30.00	—	60.00
China clay (Kaolin), domestic, lump	ton	10.00	—	20.00
China clay (Kaolin), domestic, powdered	ton	25.00	—	40.00
Feldspar	ton	11.00	—	15.00
Fluorspar, acid grade, lump, f.o.b. mines	net ton	$30.00	—	$35.00
Fluorspar, acid grade, ground, f.o.b. mines	net ton	35.00	—	45.00
Fuller's earth, domestic, powdered	ton	30.00	—	40.00
Fuller's earth, imported, powdered	ton	.....	—	.....
Pumice stone, imported	lb.	.03	—	.06
Pumice stone, domestic	lb.	.02½	—	.....
Shellac, TN	lb.	.60	—	.....
Shellac, D.C.	lb.	.....	—	.....
Shellac, V. S. O.	lb.	1.15	—	.....
Shellac, Diamond I.	lb.	.....	—	.....
Shellac, orange, fine	lb.	.88	—	.....
Shellac, orange, superfine	lb.	1.00	—	1.15
Shellac, A.C. garnet	lb.	.90	—	.....
Shellac, bleached, bone dry	lb.	1.15	—	.....
Shellac, bleached, fresh ground	lb.	1.00	—	.....
Soapstone	ton	15.00	—	25.00
Talc, domestic	ton	16.00	—	60.00
Talc, imported	ton	55.00	—	60.00

Refractories

Following prices are f. o. b. works:

Chrome brick	net ton	90–100 at Chester, Penn.
Chrome cement	net ton	45–50 at Chester, Penn.
Clay brick, 1st quality fireclay	net ton	35–45 at Clearfield, Penn.
Clay brick, 2nd quality	net ton	30–35 at Clearfield, Penn.
Magnesite, dead burned	net ton	50–55 at Chester, Penn.
Magnesite brick, 9 x 4½ x 2½ in.	net ton	80–90 at Chester, Penn.
Silica brick	net ton	41–45 at Mt. Union, Penn.

Ferro-alloys

All prices f. o. b. works.

Ferro-carbon-titanium, 15–18%, f.o.b. Niagara Falls, N. Y.	net ton	$220.00	—	.....
Ferro-chrome, per lb. of Cr. contained, 6–8% carbon	lb	.32	—	$0.40
Ferro-chrome, per lb. of Cr. contained, 2–4% carbon	lb.	.70	—	.....
Ferro-manganese, 70-80% Mn	gross ton	100.00	—	125.00
Spiegeleisen, 16-20% Mn	gross ton	35.00	—	50.00
Ferro-molybdenum, per lb. of Mo	lb.	2.00	—	3.00
Ferro-silicon, 50%	gross ton	90.00	—	115.00
Ferro-silicon, 75%	gross ton	150.00	—	175.00
Ferro-silicon, 10–15%	gross ton	45.00	—	60.00
Ferro-tungsten, 70-80%, per lb. of contained W.	lb	1.30	—	1.60
Ferro-uranium, 35-50% of U	lb.	7.00	—	.....
Ferro-vanadium, 30-40%, per lb. of contained V.	lb.	5.50	—	7.00

Resales and overstocks make above prices approximate.

Ores and Semi-finished Products

Chrome ore, 35-40%, Cr_2O_3	unit	$0.70		
Chrome ore, 48% and over	unit	.80	—	
Coke, foundry, f.o.b. mines	net ton	5.00	—	$5.50
Coke, furnace, f.o.b. mines	net ton	4.50	—	5.00
Petroleum coke, f.o.b. Atlantic seaboard	net ton	16.00	—	16.50
Fluorspar, gravel, f.o.b. mines	net ton	20.00	—	25.00
Manganese ore, 45% Mn and over	unit	.60	—	.65
Manganese ore, chemical (MnO_2)	gross ton	60.00	—	70.00
Molybdenite, 85% MoS_2, per lb. of MoS_2	lb.	.75	—	.85
Tungsten, Scheelite, 60% WO_3 and over per unit of WO_3	unit	9.00	—	11.50
Tungsten, Wolframite, 60% WO_3 and over, per unit of WO_3	unit	6.50	—	8.00
Uranium oxide, 96%	lb.	.....	—	.....
Vanadium pentoxide, 99%	lb.	6.00	—	.....
Pyrites, foreign, lump	unit	.15	—	.....
Pyrites, foreign, fine	unit	.15	—	.....
Pyrites, domestic, fine	unit	.14	—	.....
Ilmenite, 50% TiO_2	net ton	30.00	—	.....
Rutile, 95% TiO_2	net ton	200.00	—	.....
Carnotite, mimmum 2% U_3O_8, per lb. of U_3O_8	lb.	2.75	—	3.00

Resales and overstocks make above prices approximate.

Plant Materials and Supplies

In carload lots, New York, unless otherwise stated.

BUILDING MATERIALS

Portland cement, at dock, without bags	bbl.		$2.30
Lump lime, common, including container	300 bbl.		2.65
Common brick, at dock	M.		15.00
Hollow building tile, 8x12x12	M.		194.40
At factory, Perth Amboy, N. J. 12x12x12	M.		291.60
Yellow pine, 3x4 to 8x8, 20-24 ft. long	M.		40.00
Yellow pine, 3x4 to 8x8, 20-24 ft. long at Chicago	M.		39.50
Yellow pine, 3x4 to 8x8, 20-24 ft. long at St. Louis	M.		37.00
Roofings, tar felt (14 lb. per 100 sq.ft.)	ton		60.00
Roofings, tar pitch (in 400-lb. bbl.)	ton		21.00
Roofings, asphalt pitch	ton		34.00
Roofings, asphalt felt	ton		63.00
Roofings, slate-surfaced, per roll of 108 sq.ft.			2.00
Roofings, slate-finished shingles, 100 sq.ft.			5.00
Linseed oil, raw in barrels	gal.		1.93
Linseed oil, 5 gal. cans	gal.		2.06
Red lead, dry, 100 lb. keg	lb.		.13
Red lead, in oil, 100 lb. keg	lb.		.14½
Red lead, dry, 5 lb. cans	lb.		.15
Red lead, in oil, 5 lb. cans	lb.		.16½
White lead, dry and in oil, 100 lb. keg	lb.		.13
White lead, dry and in oil, 25 and 50 lb. kegs	lb.		.13½
White lead, dry and in oil, 5 lb. cans	lb.		.15

STRUCTURAL STEEL, MILL, PITTSBURGH

Beams and channels, 3 to 15-in.	100 lb.	$2.45
Angles, 3 to 6-in., ¼-in. thick	100 lb.	2.45
Tees, 3-in. and larger	100 lb.	2.45
Plates	100 lb.	2.66
Rivets, structural, ½-in. and larger	100 lb.	4.20
Rivets, conehead for boilers, ½-in. and larger	100 lb.	4.30
Sheets, No. 28 black	100 lb.	4.35
Sheets, No. 10 blue annealed	100 lb.	3.55
Sheets, No. 28 galvanized	100 lb.	5.70

For painted corrugated sheets, add 30c. per 100 lb. for 25 to 28 gage; 25c. for 19 to 24 gage; for galvanized corrugated sheets, add 15c., all gages.

INDUSTRIAL

Financial, Construction and Manufacturers' News

Construction and Operation

Arizona

DUNCAN—The Ash Peak Mines Co. plans to build a mill to have a yearly capacity of 45,000 tons. A. Murphy, superintendent.

GLOBE—The Gila Monster Co. plans to build a 10 stamp mill and is in the market for a crusher, two tables, six tanks and an 80 hp. engine. Estimated cost, $50,000. W. H. Seaman, superintendent. Noted May 15.

GLOBE—The Jumbo Mining Co. plans to build a 25-ton cyanide mill to handle tailings. W. T. Bessonnette, Waco, Tex., superintendent.

MIAMI—The Greater Miami Mining & Milling Co. plans to build a 100-ton concentration mill.

MIAMI—The Miami Mining & Milling Co. plans to build a 50-ton concrete flotation mill at Dook Station, near the Arizona Eastern Railway.

TUSCON—The Yellow Bird Mining Co. plans to build a silver lead furnace at its property 32 miles west of Tuscon to treat 50 tons daily. S. W. Purcell, manager.

WINKLEMAN—The Aztlan Mining Co. will build a 100-ton mill and is in the market for equipment for same. Estimated cost, $150,000. H. Whitcomb, manager.

California

AVALON—The city voted $55,000 bonds for the construction of a gas plant. A. B. Waddingham, Tajo Building, Los Angeles, city engineer.

BISHOP—A. D. Schiveley, town clerk, rejected bids opened June 2 for the construction of a sanitary sewerage system and sewage treatment tank. Estimated cost, $35,000. New bids will soon be received. Olmsted & Gillelen, 1112 Hollingsworth Building, Los Angeles, engineers.

WASHINGTON — W. F. McCutcheon, San Francisco, plans to rebuild its 40-stamp mill, compressor building, etc., near here, recently destroyed by fire. W. L. Williamson, superintendent.

Connecticut

MIDDLETOWN—The trustees of the Wesleyan University plan to build a new chemical laboratory building on the campus. Estimated cost, $100,000.

NEW HAVEN—The Seamless Rubber Co., 534 Congress St., has awarded the contract for the construction of a plant on Hallock Ave. to the Aberthaw Construction Co., 27 School St., Boston, Mass. Estimated cost, $500,000.

District of Columbia

WASHINGTON—The Army War College received bids for the construction of a photographic laboratory, from E. Diebitsch, 383 Madison Ave., New York, N. Y., $60,994 (100 days); Weller Construction Co., 816 14th St., $65,893 (160 days); Piel Construction Co., 2519 Edmonston Ave., Baltimore, Md., $68,750 (120 days).

Florida

WEST PALM BEACH—The City Council will soon receive bids for the construction of a large filtration plant. G. W. Simmons, Jacksonville, engineer.

Indiana

INDIANAPOLIS—The Board of Sanitary commissioners, City Hall, will receive bids until July 11 for the construction of a sewage disposal plant for the sanitary district. J. A. Craven, secretary.

Iowa

CLINTON—The Board of Education will receive bids in August for the construction of a two-story, 206 x 226-ft. high school. Plans include a chemistry room, physics supply room, etc. Total estimated cost, $300,000. A. H. Paddock, secretary, Miller, Fullenwider & Dowling, 6 North Michigan Ave., Chicago, Ill., architects.

Louisiana

BATON ROUGE—The Aluminum Ore Co., St. Louis, Mo., plans to build a bauxite ore refinery here.

Maryland

MD., CANTON (Baltimore P. O.)—The Porcelain Enamel & Manufacturing Co., O'Donnell and 8th Sts., will build a 1-story, 100 x 110-ft. addition to its enameling plant. Estimated cost, $12,500.

HIGHLANDTOWN (Baltimore P. O.)—Jones & Lamb Co., Pennsylvania and Fulton Aves., Baltimore, will soon receive bids for converting the plant of the Monumental Brewery Co., on Lombard St., into a meat packing plant and oil refinery. Estimated cost, $500,000. C. B. Comstock, 110 West 40th St., New York, N. Y., engineer. Noted May 15.

SOUTH BALTIMORE (Baltimore P. O.)—The Standard Guano Co., 1214 Continental Building, Baltimore, will build a 2-story, 104 x 400-ft. fertilizer factory on Aspen St., near Pennington Ave. Estimated cost, $96,000. P. S. Gilchrist, 601 Park Ave., Charlotte, N. C., architect.

Massachusetts

FITCHBURG—Crocker, Burbank & Co., Inc., 545 Westminster St., will soon receive bids for the construction of a 2-story, 60 x 200-ft. factory for the manufacture of paper. Estimated cost, $100,000.

MALDEN—The Boston Dye House has awarded the contract for the construction of a 3-story, 40 x 100-ft. dye house, a 1-story, 30 x 60-ft. naphtha house, and a 1-story garage, on Main and Eastern Sts., to C. H. Tenney & Co., Devonshire. Estimated cost, $50,000.

WESTFIELD—The National Pulp Corporation, 505 5th Ave., New York City, N. Y., plans to build a plant on the Westfield River. Estimated cost, $200,000.

Michigan

ESCANABA—The Escanaba Wood Fibre Co. plans to build a 3-story paper mill. Estimated cost, $750,000.

SAGINAW—The Saginaw News-Courier, South Wart St., plans to build a 1- and 2-story, 48 x 132-ft. newspaper plant on South Washington St. Cowles & Mutschelle, 114 North Washington St., architect.

Missouri

ST. LOUIS—The Mineral Refining & Chemical Corp., Iron Mountain Tracks and River Des Peres, is in the market for chemical and mineral dryers.

New Jersey

JAMESBURG—The Department of Agriculture, 142 West State St., Trenton, will receive bids until June 25 for the construction of a sewerage system at the State Home for Boys, to include a 54-ft. stone filter bed, sludge bed, etc. Estimated cost, $10,000. F. H. Bent, 142 West State St., Trenton, engineer.

NEWARK — The Wallington Leather Works, 42 Kent St., has awarded the contract for the construction of a 2 story, 48 x 50-ft. tannery, to J. R. Robinson, 274 South St. Estimated cost, $8,000.

PALMYRA—The city plans to build a sanitary sewerage system to include a combined sewage pumping station and disposal works for treating sewage of both Riverton and Palmyra. Estimated cost, $125,000. Remington & Vosbury, 601 Market St., Camden, engineers.

TRENTON—The Albano Manufacturing Co., 40 General Green Ave., plans to build a 1-story, 60 x 125-ft. factory for the manufacture of shoe paste. Estimated cost, $12,000. P. L. Fowler, 317 Broad St. Bank Building, architect.

WESTMONT—The city plans to build a sanitary sewerage system to include sewage ejector station and treatment works. Remington & Vosbury, 601 Market St., Camden, engineers.

New York

LONG ISLAND CITY—The Patterson-Sargent Co., 8 Jay St., New York City, will soon receive bids for the construction of a 4-story, 40 x 110-ft. addition to its paint factory on Van Dam St. and Borden Ave. here. Estimated cost, $200,000. Ballinger & Perrott, 47 West 34th St., New York City, engineer.

NORTH TONAWANDA — The Buffalo Bolt Co., Tonawanda, has awarded the contract for the construction of an 80 x 170-ft. addition to its rolling mill and 40 x 340-ft. addition to its tumbling room, to the Lackawanna Bridge Co., Bell and Abbey Sts., Buffalo. Estimated cost, $60,000.

PIERREPONT MANOR—The Northern New York Milk Co., recently incorporated with $500,000 capital stock, will install laboratory equipment for both dry and condensed milk plant, in connection with the milk station, evaporating plant and milk shipping station which it plans to build. Estimated cost, $200,000. Address F. P. Redfield, Adams, director.

SYRACUSE—The B. G. H. Metal Manufacturing Co., 106 South State St., has purchased a site at 108-112 South State St., and plans to build a 3-story plant. Estimated cost, $25,000. W. E. Sias, secretary.

North Carolina

RALEIGH—The International Vegetable Oil Co. will build an addition to its oil plant, here. Estimated cost, $30,000. W. F. Marsh, manager.

Ohio

CINCINNATI—The Chas. Boldt Paper Mill Co., 5500 Eastern Ave., plans to build a 1-story, 48 x 106-ft. and 46 x 320-ft. addition to its paper mill. C. Boldt, president.

COLUMBUS—M. Peterman, architect, Rector Building, is receiving bids for the construction of a 1- and 2-story addition to the cleaning plant of the Buckeye Cleaning Co., Main St. and Alum Creek.

DAYTON—The Dayton Oxygen & Hydrogen Products Co., U. B. Annex, has awarded the contract for the construction of a 2-story, 60 x 180-ft. factory on South Broadway, to the Blanchard Building Co., Dayton. Estimated cost, $45,000.

MARION—B. H. Bair plans to build two buildings, 2-story, each 20 x 20 ft., for dry cleaning plant. F. D. Jacobs, Church St., architect.

MIDDLETOWN — The Gardner-Harvey Paper Co. has awarded the contract for the construction of a 2-story, 35 x 250-ft. paper mill, to Frank Hill Smith, Inc., West 3rd St., Dayton. Estimated cost, $30,000.

SPRINGFIELD—The Ohio Steel Foundry Co., Lagonda Ave. and Gothic St., will build a welding building, garage and research laboratory. Estimated cost, $25,000.

Oklahoma

ENID—The city plans an election soon to vote on $1,000,000 bonds; $300,000 to be used for waterworks improvements and extensions, and $175,000 for the construction of a sewage disposal plant, etc. Black & Veatch, Interstate Building, Kansas City, Mo., engineers.

OKLAHOMA CITY—The Hazelrigg Laboratories, incorporated with $50,000 capital by V. T. Hazelrigg, president, and Dr. J. E. Harbison, 310 Mercantile Building, treasurer, plans to build a plant. Project includes the largest chemical, bacteriological and serological laboratories in the Southwest.

TULSA—The trustees of the Henry Kendall College, Cleland and 7th Sts., are having revised plans prepared for the construction of a gymnasium. Plans include the installation of a filtration plant, etc. C. E. Buchner, chairman.

Oregon

CORVALLIS—The Board of Regents of the State Agricultural College has awarded the contract for the construction of a 2-story, 56 x 220-ft. engineering laboratory on the college campus, to Snook & Travers, Albany, $69,987. Noted June 15.

Pennsylvania

FULTON—The National Metal & Moulding Co., Fulton Building, Pittsburgh, plans to build a 1-story, 130 x 250-ft. addition to its plant, here.

ALTO—The State Department of Health, Harrisburg, has awarded the contract for constructing and equipping extensions to

the sewage disposal plant at the State Sanitarium for Tuberculosis, near here, to Simpson & Brown, 90 West St., New York City, $23,031.

PHILADELPHIA—The Keystone Pure Oil Co., Broad St., below Huntington St., has awarded the contract for the construction of a 2-story, 76 x 150-ft. factory, to F. A. Havens, 845 North 19th St. Estimated cost, $40,000.

PITTSBURGH—The Damascus Bronze Co., 928 South St., plans to build an 80 x 80-ft. addition to its plant.

South Carolina

ANDREWS—The City Council will soon receive bids for laying sewer mains and constructing a sewage disposal plant. Estimated cost, $50,000. Tomlinson Engineering Co., Loan & Exchange Bank Building, Columbia, engineers.

BATESBURG—The city plans an election July 11, to vote on $40,000 bonds for the construction of a sewerage system, to include a septic tank, etc.

Tennessee

KNOXVILLE—The Day Pulverizer Co. plans to build a 1-story addition to its plant, also install machinery in same.

Texas

WICHITA FALLS—The Committee of the Northwest Texas Insane Asylum will soon award the contract for the construction of an administration building at the asylum here, including sewage disposal plant, etc. Total estimated cost, $350,000. C. H. Page & Bros., Austin National Bank Building, Austin, architect.

Washington

SEATTLE—Dr. J. Wilkins, Cobb Building, has awarded the contract for the construction of a 3-story, 34 x 60 x 70-ft. hospital on 16th and John Sts., to P. T. Bratt, 4902 Phinney Ave. Plans include the installation of an X-ray laboratory. Estimated cost, $55,000. J. R. Nevins, Hoge Building, architect.

West Virginia

CHARLESTON — The Superior Red Granite Co., 813 Kanawha Building, plans to build a granite crushing plant, and is in the market for 4 crushers having a daily capacity of eight cars of granite.

WESTON—The State Board of Control, Charleston, has awarded the contract for the construction of a sewage disposal plant at the Weston State Hospital, here, to C. E. Collins, Drexel Building, Philadelphia, Pa. Estimated cost, $45,000. Noted June 1.

Wisconsin

CARROLLVILLE (Otjen P. O.)—The United States Fertilizer Co., c/o the United States Glue Co., will soon award the contract for the construction of a 2- and 3-story, 67 x 219 and 50 x 50-ft. fertilizing plant. Estimated cost, $100,000. H. J. Esser, Camp Building, Milwaukee, architect.

GREEN BAY—The Fort Howard Paper Co. has awarded the contract for the construction of a 1-story, 49 x 135-ft. factory, to Ludolph Hansen, 114 South Maple St. Estimated cost, $45,000. Noted April 1.

MILWAUKEE—The Pfister & Vogel Leather Co., Virginia St., has awarded the contract for the construction of a 2-story, 60 x 150-ft. addition to its tannery on Bay View St., to C. A. Kleppe, 1026 1st St. Estimated cost, $30,000.

TWO RIVERS—The Board of Education will install laboratory equipment in the 3-story, 80 x 155-ft. high school which it plans to build on Main St. Total estimated cost, $125,000. T. D. Chubb, 109 Dearborn St., Chicago, Ill., architect.

Nova Scotia

TIVERTON—The Digby Fish Meal Co. will soon receive bids for the construction of a 3-story, 60 x 100-ft. factory on Queen St. for the manufacture of fish meal and extraction of oil. Estimated cost, $25,000.

Ontario

KINGSTON—The Department of Public Works, Ottawa, will soon award the contract for the construction of a sewerage system and disposal works at the Sydenham Hospital, here. Estimated cost, $100,000.

KINGSTON — The Municipal Council plans to expend $30,000 for new purifiers, $10,000 for liners and $10,000 for generators to be installed in the gas plant.

OWEN SOUND—J. Legate, chairman of the Utilities Commission will soon award the contract for the construction of a concrete slow sand filter at No. 1 spring, Derby Township. Estimated cost, $35,000.

OWEN SOUND—The Utilities Commission is receiving bids for furnishing a slow sand filter. R. McDowell, engineer.

ST. CATHERINES—The city plans to build sanitary sewers and a sewage disposal plant. Estimated cost, $50,000. W. P. Near, City Hall, engineer.

Quebec

GRANBY—The Miner Rubber Co., 72 St. Peter St., has awarded the contract for the construction of a rubber factory to the Dominion Bridge Co., 285 Beaver Hall Hill, Montreal. Estimated cost, $35,000.

MONTREAL—The Scot-Canadian Magnesite Co., Ltd., Power Building, plans to build a plant on Shawinigan St. Estimated cost, $350,000.

VAL JALBERT—The Chicoutimi Paper & Pulp Co., Chicoutimi, is having plans prepared by L. Lamontagne, architect, Chicoutimi, for the construction of a factory. Estimated cost, $75,000.

Industrial Notes

ARTHUR D. LITTLE, INC., of Cambridge, Mass., has designed and is installing improvements and enlargements in the plant of the Minute Tapioca Co. at Orange, Mass.

THE NATIONAL REDUCTION CO. is building a large rosin and turpentine plant at Calvert, Ala., designed and erected by Arthur D. Little, Inc., of Cambridge, Mass.

THE NEW YORK TESTING LABORATORIES have been organized by Messrs. L. R. Seidell, G. B. Jack, Jr., and H. H. Geist, formerly chief metallurgist, assistant chief metallurgist and chief chemist respectively of the Wright-Martin Aircraft Corp. The laboratories are at 354 Mulberry St., Newark, N. J., and the New York office is established at 74-80 Washington St. In addition to chemical and physical testing and microphotography, this organization is specializing in the source inspection of materials, and as consultant in smelting foundry, drop-forging and heat-treating practices and the metallurgical investigation of shop troubles.

THE CARRIER ENGINEERING CORP., announces that Mr. E. P. Heckel has been made vice-president of the corporation and transferred from New York to Chicago as Western manager. Mr. A. E. Stacey, formerly Western manager, has been transferred to New York as head of the department of research and development.

BECKMAN & LINDEN CORP., San Francisco, Cal., has installed a 100-kw. single-phase electric furnace for commercial testing and research on the electric smelting possibilities of the Pacific Coast region.

THE METAL & THERMIT CORPORATION, New York, has recently completed the largest marine weld ever recorded, on the cast steel sternframe of the huge U. S. Army Transport Northern Pacific. The section welded was entirely broken through as a result of the severe strain to which the frame was subjected when this transport, laden with homeward-bound troops, ran aground on Jan. 2, 1919, in a dense fog, off Fire Island, New York. The weld required 1400 lb. of thermit for the chemical production of the necessary amount of molten steel, and was made without removing the casting from the ship.

THE CHEMICAL FOUNDATION, INC. has opened offices at 81 Fulton St., New York City and is ready to discuss the issuance of licenses for the various German chemical and metallurgical patents which it controls. Licensees must be all-American and possess ability and equipment to manufacture under the license.

Coming Meetings and Events

THE AMERICAN CERAMIC SOCIETY will hold a meeting in Chicago, Sept. 24.

THE AMERICAN CHEMICAL SOCIETY will hold its Fall meeting in Philadelphia, Pa., Sept. 2-6 inclusive.

THE AMERICAN ELECTROCHEMICAL SOCIETY will hold its Fall meeting in Chicago, Sept. 23-25 inclusive.

THE AMERICAN ELECTRO-PLATERS' SOCIETY will hold its 1919 convention in Philadelphia, Pa., July 1-3.

THE AMERICAN FOUNDRYMEN'S ASSOCIATION will hold its 1919 convention in Philadelphia, Sept. 29 to Oct. 4.

THE AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS will hold its Fall meeting in Chicago, Ill., Sept. 22-27.

THE AMERICAN STEEL TREATERS' SOCIETY will hold its first annual convention in Chicago, Ill., Sept. 22-27.

THE FIFTH NATIONAL EXPOSITION OF CHEMICAL INDUSTRIES will be held in Chicago, Ill., Sept. 22-27 inclusive.

THE INSTITUTE OF METALS DIVISION of the A. I. M. E. will hold its next meeting in Philadelphia, Pa., Sept. 29 to Oct. 4.

THE INSTITUTE OF METALS will hold its Autumn meeting in Sheffield, England, Sept. 24-25.

THE INTERALLIED CHEMICAL CONFEDERATION will hold its next meeting in London, July 15-18, 1919.

THE TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY will hold its Fall meeting in Chicago from Sept. 24 to 27.

THE SOCIETY OF CHEMICAL INDUSTRY will hold its annual general meeting in London July 15-18, 1919.

Stocks and Bonds

Closing Bid and Asked Quotations June 26, on N. Y. Stock Exchange

CHEMICAL COMPANIES

	Bid	Ask		Bid	Ask
Am.Ag.Ch.....	108	109	Mat.Al.Wk..	31	40
do.pf.....	99½	100	Ten. C. & C..	13½	13¾
Barrett Co...	132	134	Un. Dyewood.	63	70
do.pf.....	116½	117½	do. pf.....	97	97½
Gen.Chem.....	185	199	Va.-Car. Ch..	82½	82½
do.pf.....	102½	108	do. pf.....	114½	115
Int.Ag.Ch....	24½	26			
do. pf.....	85	85½			

Bonds

Am. Ag. Ch., 1st cv. 5s, '28.....	98	99½
Am. Ag. Ch., cv. db. 5s, '24.....	106	114
Int. Ag. Ch., 1 mtg. & col. tr. 5s, '32....	82½	83
Va.-Car. Ch., 1 mtg. 5s, '23.....	97½	98½
Va.-Car. Ch., cv. db. 6s, '24.....	101½	102

PETROLEUM COMPANIES

	Bid	Ask		Bid	Ask
Asso. Oil Co..	91	93	P-A Pet & Tr.	93	93½
Cal. Pet.....	34	34½	do. pf.....	167	174
do. pf.....	77	77½	Pierce Oil....	23½	23½
Col. G. & E..	58½	59	Royal Dutch..	111½	112
Mex. Pet.....	183½	184	Sinclair O & R	61	61½
do. pf.....	107	108	Texas Co.....	268	269
Ohio Cit. Gas.	56½	56½	Tex. Pac. Ld. Tr.....	400	500
do. pf.....					
Ohio Fuel S...	50	50½	Tidewater Oil.	237	240
Okla. P. & R..	10½	10¾			

Bonds

Columbia Gas & Electric, 1 5s, '27.....	88	90
Col. G. & El., std. 1 5s, '27.....	88	
Pan-Am. Pet. & Tr. 1 6s, '19-'27.....	140	....
Pierce Oil, cv. db. 6s, '20.....	115	130
Pierce Oil, cv. 5% Notes, '24.....	106	106½
Sin. O. & R. 1 In.7s, '20, with stk. war....		150
Sin. O. & R. 1 In. 7s, '20 without stk. war..	99½	99½
Texas Co., db. 6s, '31.....	102½	103
Union Oil of Cal. 1 5s, '31.....	93½	94½
United Fuel Gas 1 mtg. 6s, ser.A, '36.....	94½	97

IRON AND STEEL SECURITIES

	Bid	Ask		Bid	Ask
Am. St. F.....	42	42½	Pitts. Ste. pf..	96½	98
Beth. Steel...	86½	87½	Rep. Iron & Steel.....	89½	90
do. class B.	86½	87½	do. pf.....	103½	104½
do. pf., 8%.	111½	112½	Sloss Sheff. I. & S.....	70½	70½
do. pf., 7%.	95	105	do. pf.....	93	95
Central Fdry.	21½	22	Superior Steel.	43½	44
do. pf.....	47½	49	do. 1 pf....	102	110
Col. F. & I...	46½	47½	Trans. & W. Steel.....	54	56
do. pf.....	105	125	Un. Alloy St..	51½	52
Cruc. Steel...	91½	91½	U.S.C.I.P.&F.	35½	35½
do. pf.....	100	100½	do. pf.....	63½	64½
Great No. Ore	45	45½	U. S. Steel....	107½	107½
Gulf Sta. Steel	66½	67	do. pf.....	115	115½
do. 1 pf....	94½	98	Va. Coal,I&C.	64	67
Lack. Steel...	82½	83½			
Mid.St.& Ord.	51	51½			
Nova Scotia Steel.....	81	83			

Bonds

Beth. Steel, 1 ext. gtd. S.F. 5s, '26.....	96½	96½
Beth. Steel, 1 In. ref. 5s, Ser. A, '42.....	92	92½
Beth. Steel, P. M. & I. S. F. 5s, '36.....	88	88½
Buff. & Susq. Iron, 1 S. F. 5s, '32.....	92	96
Buff & Susq. Iron, deb. 5s, '32.....	....	....
Cent. Found. 1 mtg. S. F. 6s, '21.....	80	83
Col. F. & I., gn. S. F. 5s, '43.....	90	92
Ill. Steel, db. 4½s, '40.....	85½	86
Ind. Steel, 1 mtg. gtd. 5s, '52.....	96	96½
Lack. Steel, 1 5s, '23.....	97	98
Lack. Ste., 1 con. mtg. cv. 5s, Ser. A, '50	93	95
Mid. St. & Ord., clt. cv. S. F. 5s, '36.....	89½	90½
Nat. Tube, 1 mtg. gtd. 5s, '52.....	98½	99
Rep. I. & S., S. F. mtg. 5s, '40.....	94½	95
Tenn. C. & I. R.R., gn. 5s, '51.....	93	94
U. S. Steel, S. F. 5s, '63.....	100½	101
Va. C., I. & C., 1 5s, '49.....	86	88½